Microphysics Schemes in FV3GFS

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1. IMSG; 2. EMC/NCEP; NCAR

Available MP Options in FV3GFS

|	Zhao & Carr	GFDL MP	MG1/MG2/MG3 (double)	Thompson 2008/2014 (double)
prognositic variables	qv, qc (water or ice)	qv, ql, qi, qs, qr, qg	qv, ql, ,nl, qi, ni (qr, nr, qs, ns) Aerosol aware	qv, ql, qi, qs, qr, qg, ni, nr (2008) + nc, nwfa, nifa (aerosol-aware)
condensation and evaporation	Sunqvist et al (1989)	Lin, et al (1983)	MG2008, MG2015, Barahona et al 2014	Yau and Austin (1997), Thompson and Eidhammer(2014)
mixed-phase clouds	No (simple ice)	yes	yes	yes
precipitation sedimentation	no storage in the air and instantaneous fallout	qi,qr,qs,gq sediment vertically	qc and qi sediment vertically (cloud and precip)	qi, qr, qs, qg sediment vertically (ql)

Thompson MP Winter Experiment Statistics VS Zhao & Carr MP
## – 20170105—20170228

1. **GFS14:** Current operational GFS with Zhao & Carr MP **(nemx)**
2. **FV3GFS**: Forecast only experiment; FV3 dycore with default **GFS14** physics and Zhao & Carr MP
3. **FV3TH:** Forecast only experiment; **FV3GFS** + Thompson MP (replaces Zhao & Carr)
   - Cloud species are fed into corresponding categories in the radiation; Particle effective radii calculated in the Thompson MP are used in the radiation
   - Ice number associated with the detrained cloud ice from deep and shallow convection is added to the total ice number
   - Snow is treated as ice in cloud cover calculation in radiation
   - Cloud drop number over land (300 /cm^3) is used.
   - Ice nucleation super-saturation requirement is relaxed.
   - Rhc is used in the cloud condensation and evaporation

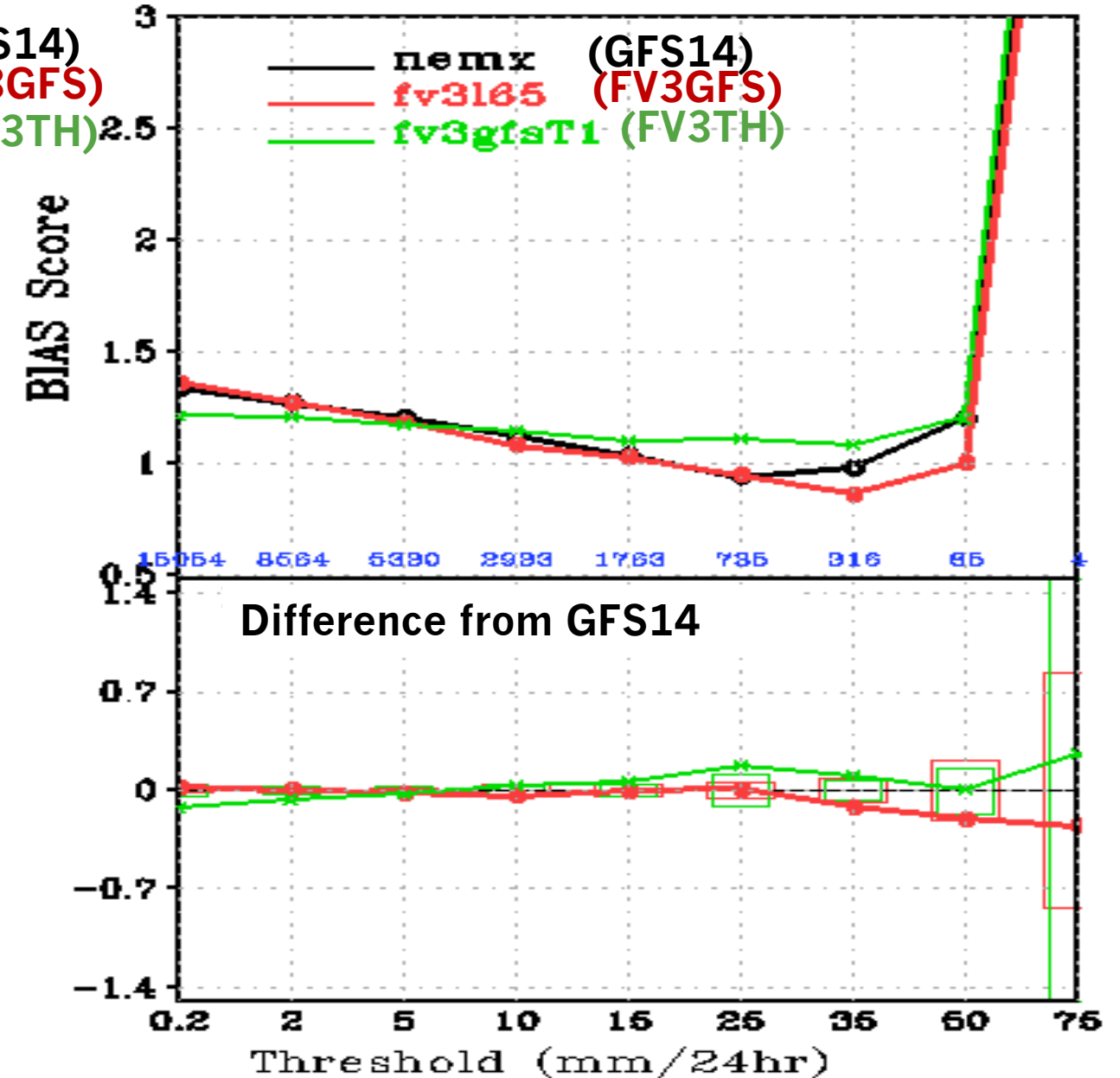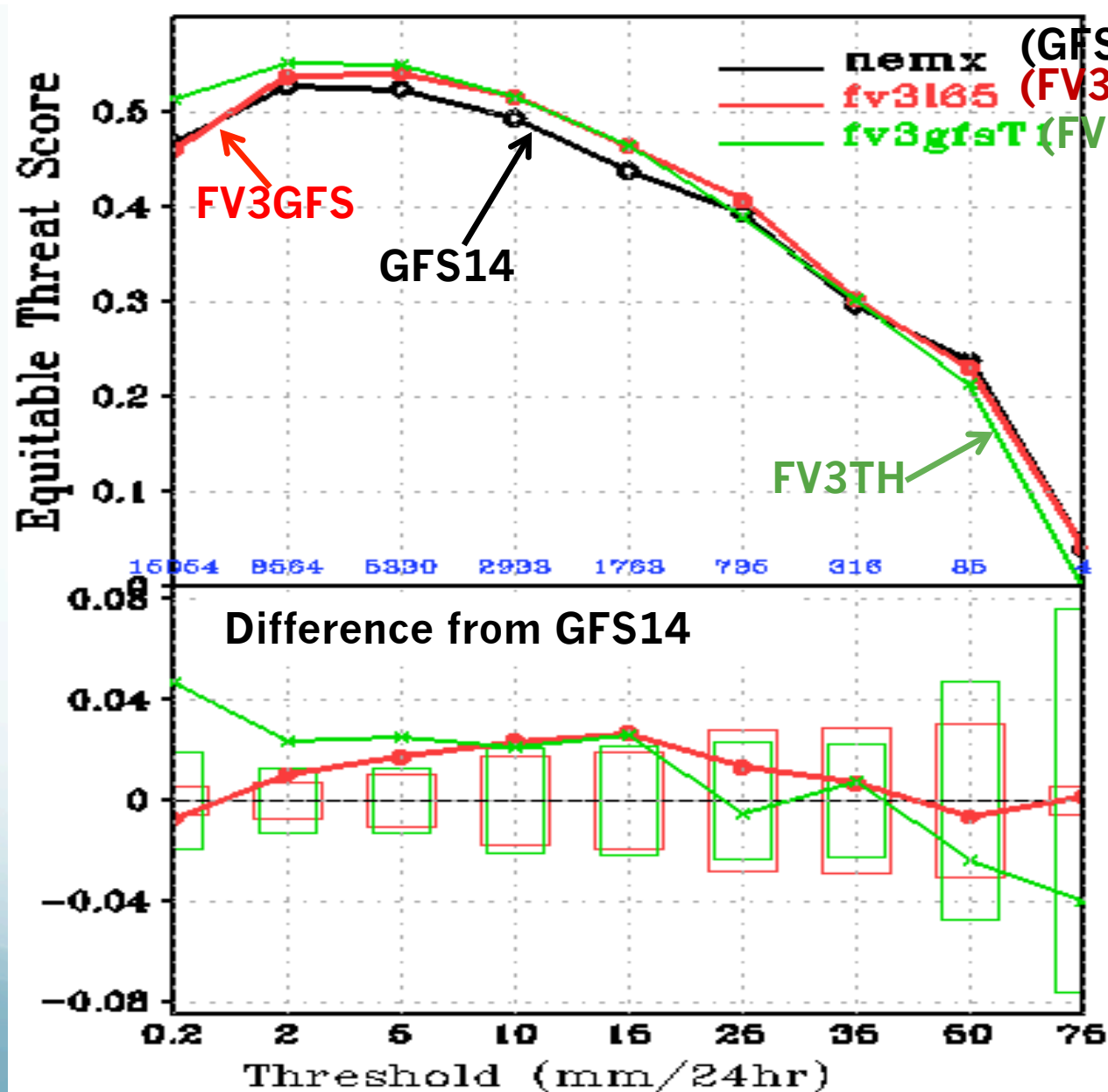# FV3TH: Cloud and Precipitation Cross Section (latitudinal average)
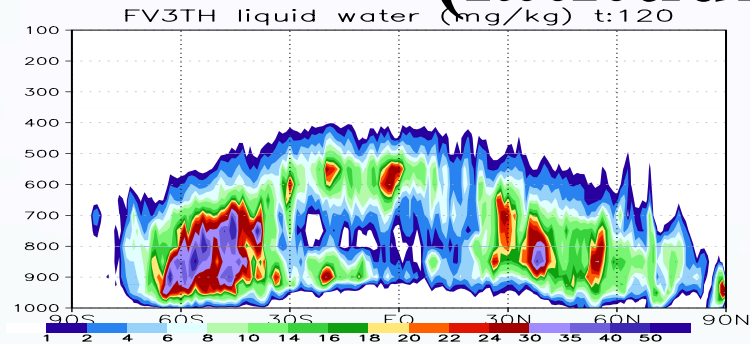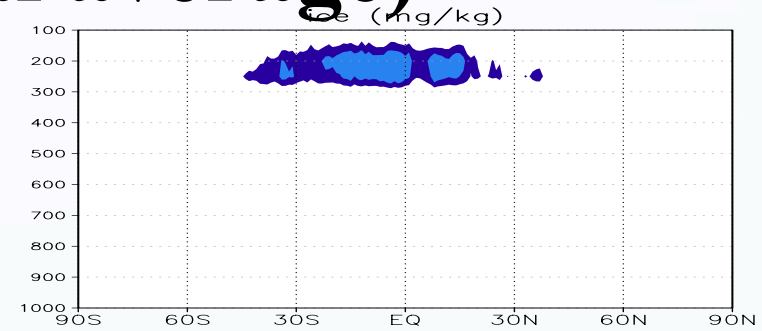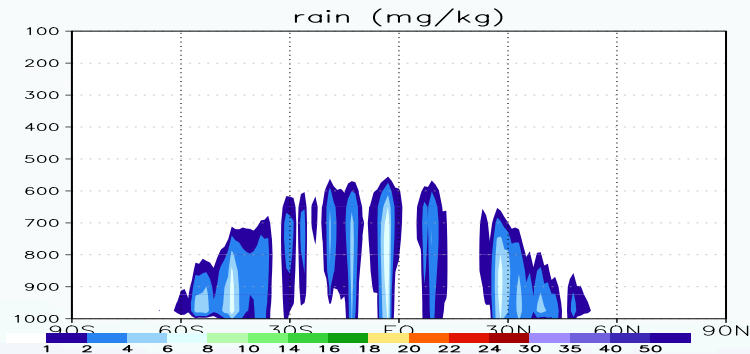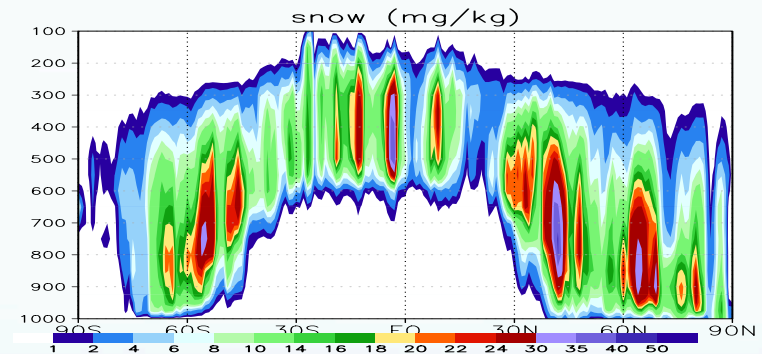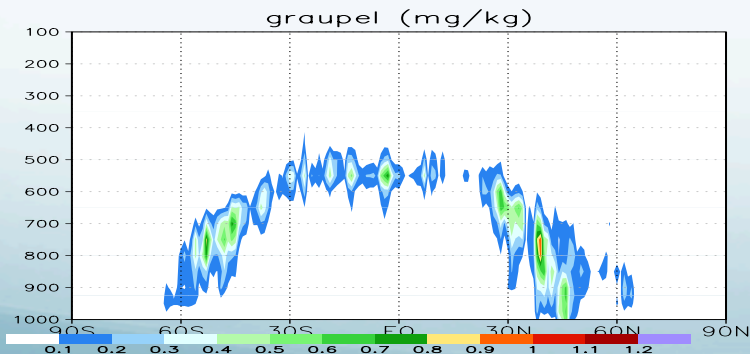
Cont. U.S. Winter 2017 Precipitation Skill Scores: Forecast hours 12-36
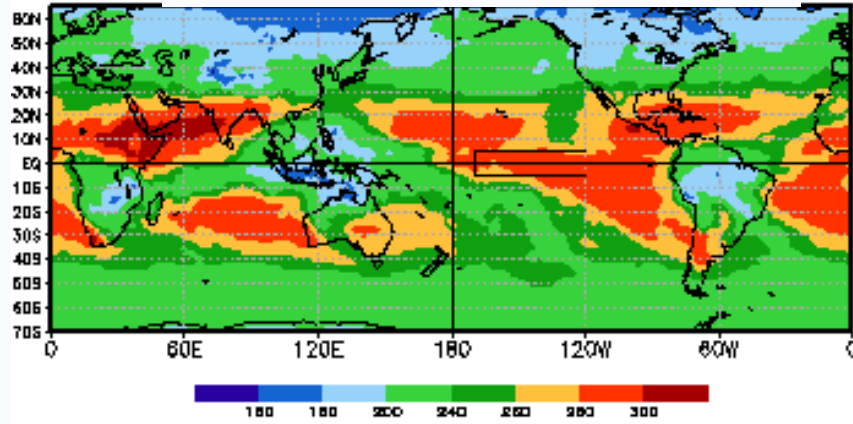

Differences outside of the hollow bars are 95% significant based on 10000 Monte Carlo Tests

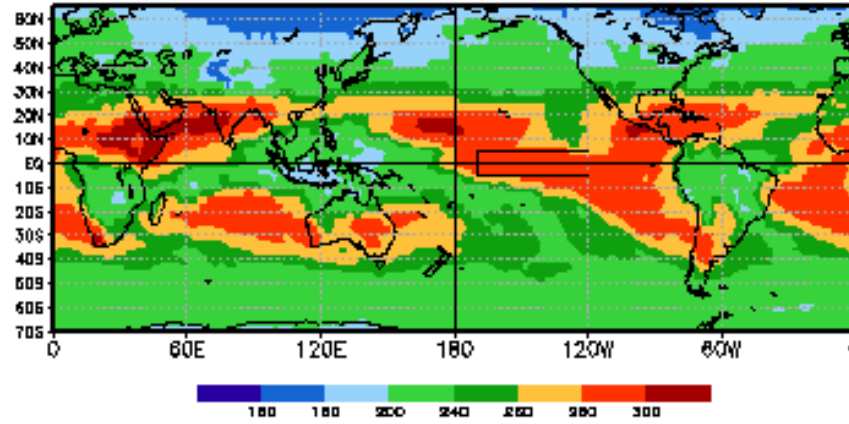# Cont. U.S. Winter 2017 Precipitation Skill Scores: Forecast hours 36-60

Differences outside of the hollow bars are 95% significant based on 10000 Monte Carlo Tests
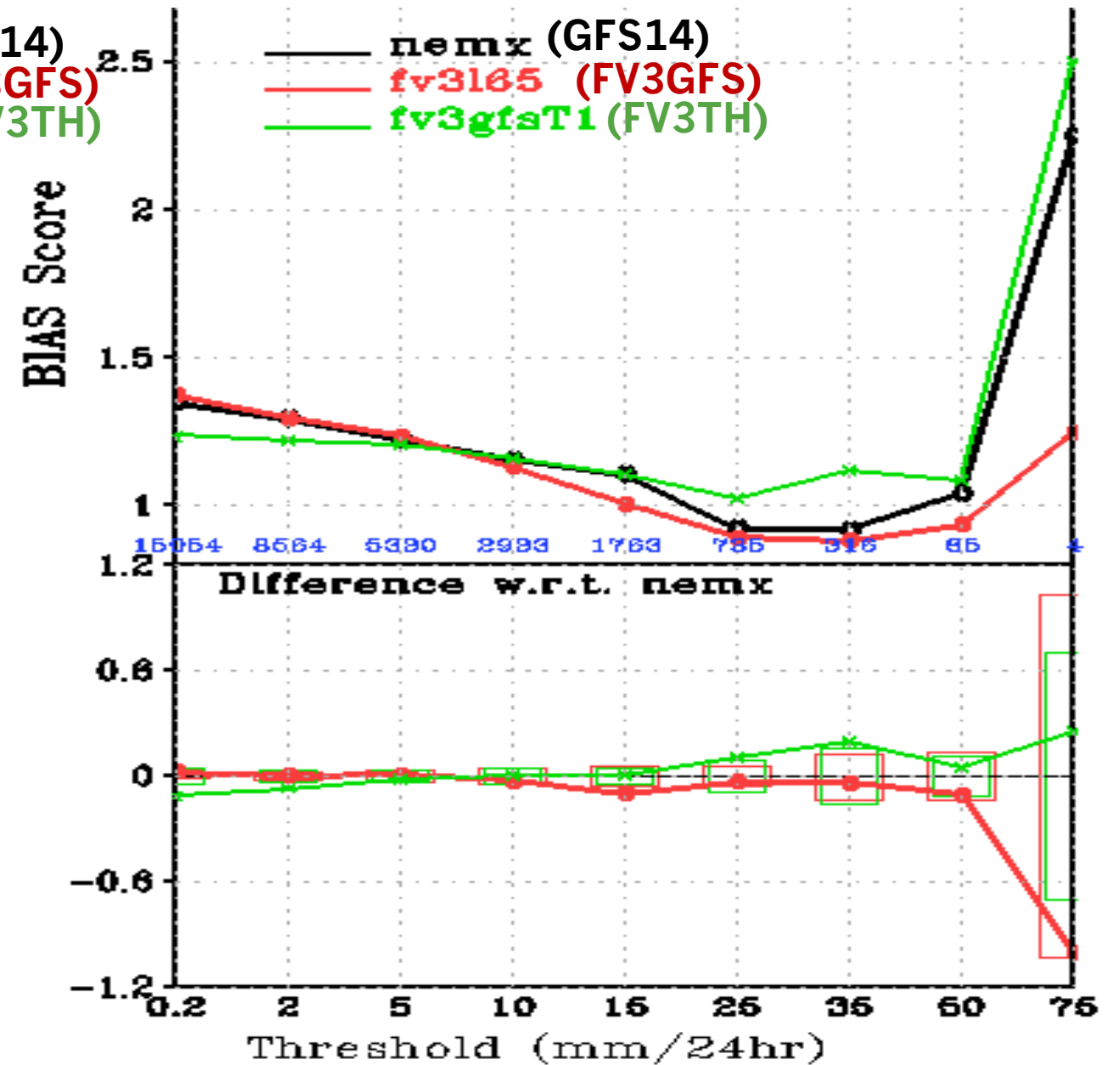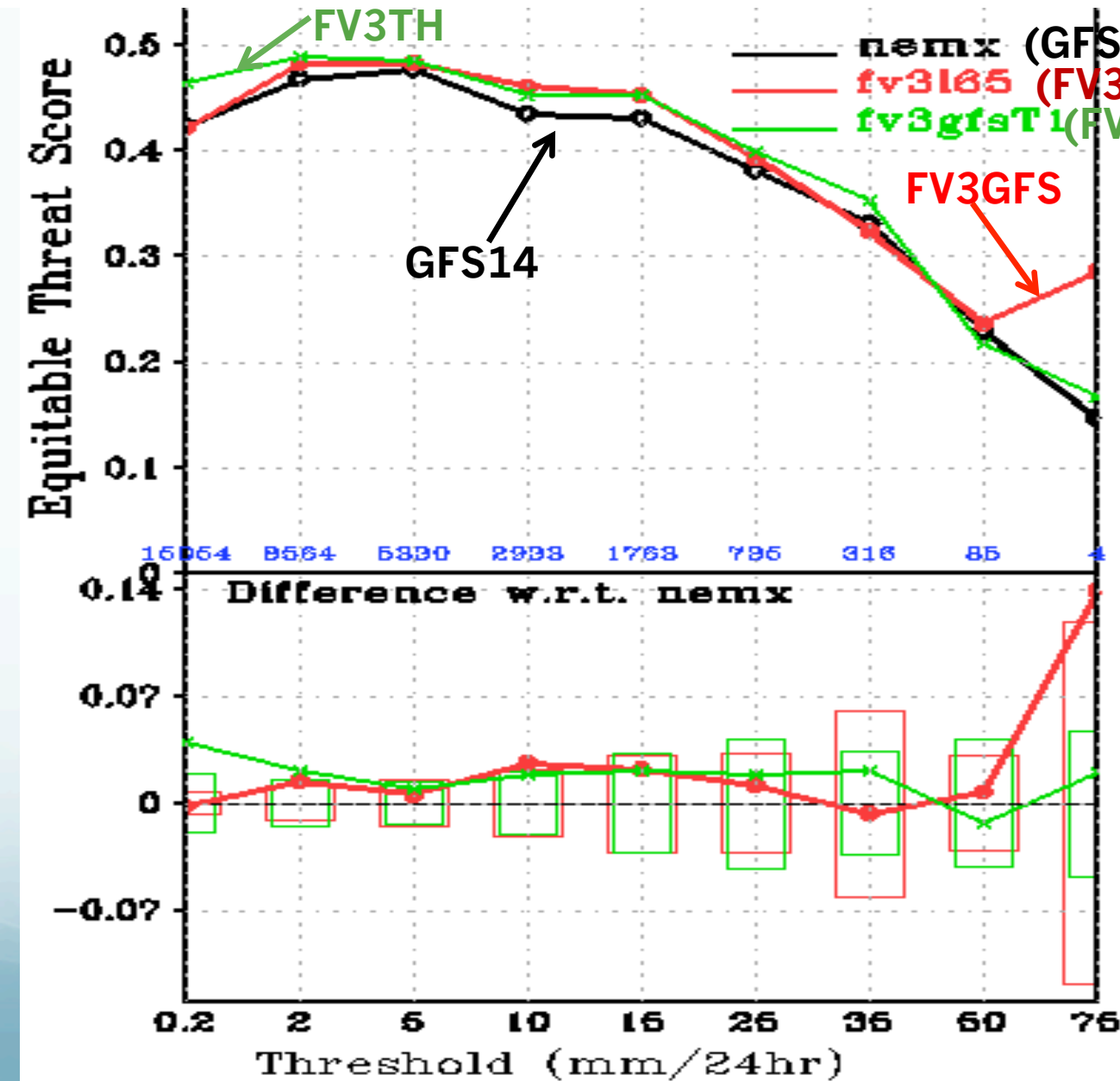
OLR (201701 monthly mean)

FV3GFS (241.2,256.9)

FV3TH (241.1,259.7)

Global mean   Tropical mean

CERES Observations (242.4,258.9)
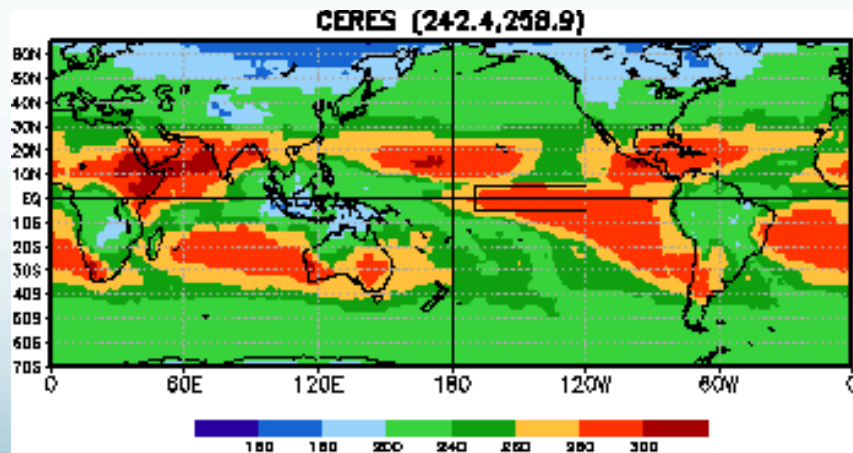
FV3TH-CERES (-1.32, 0.786)

CERES (242.4,258.9)
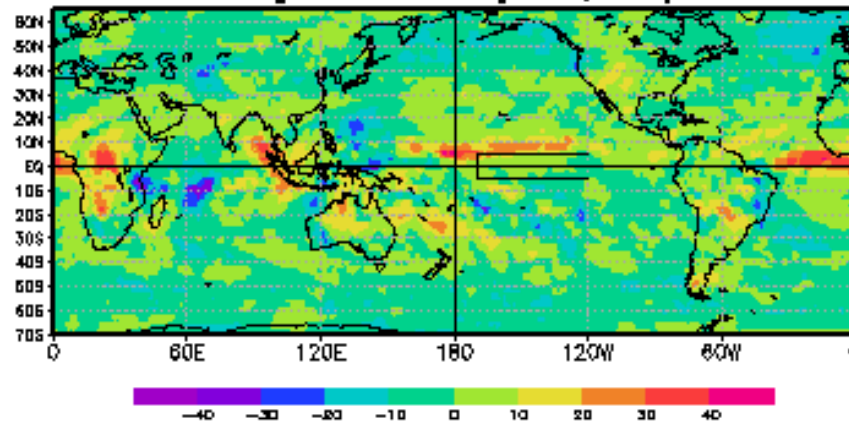
USW at TOA (201701 monthly mean)

FV3GFS (90.63,84.22)
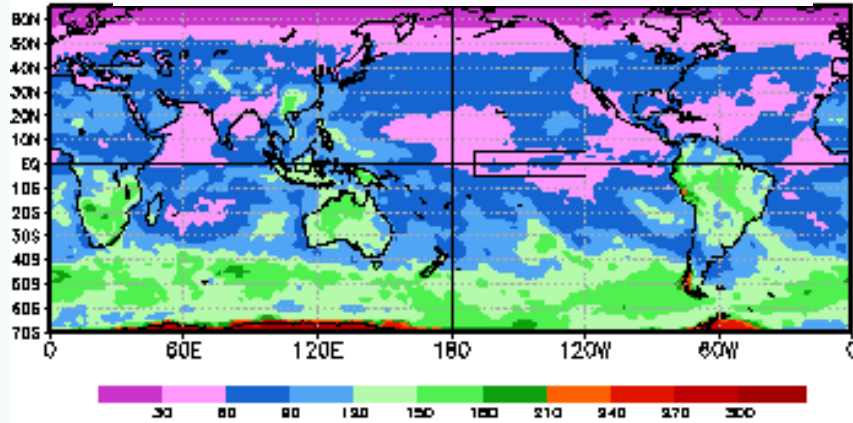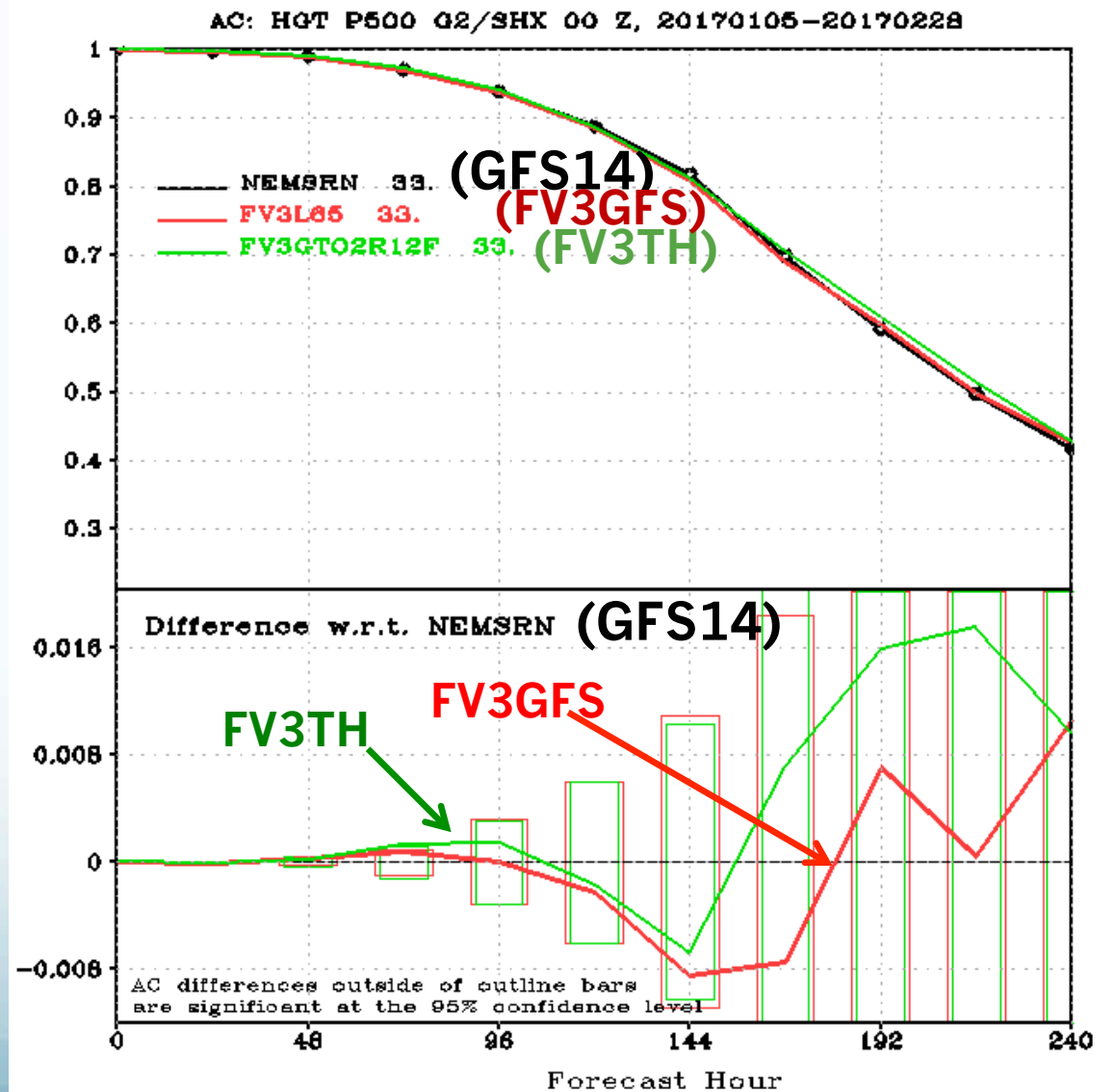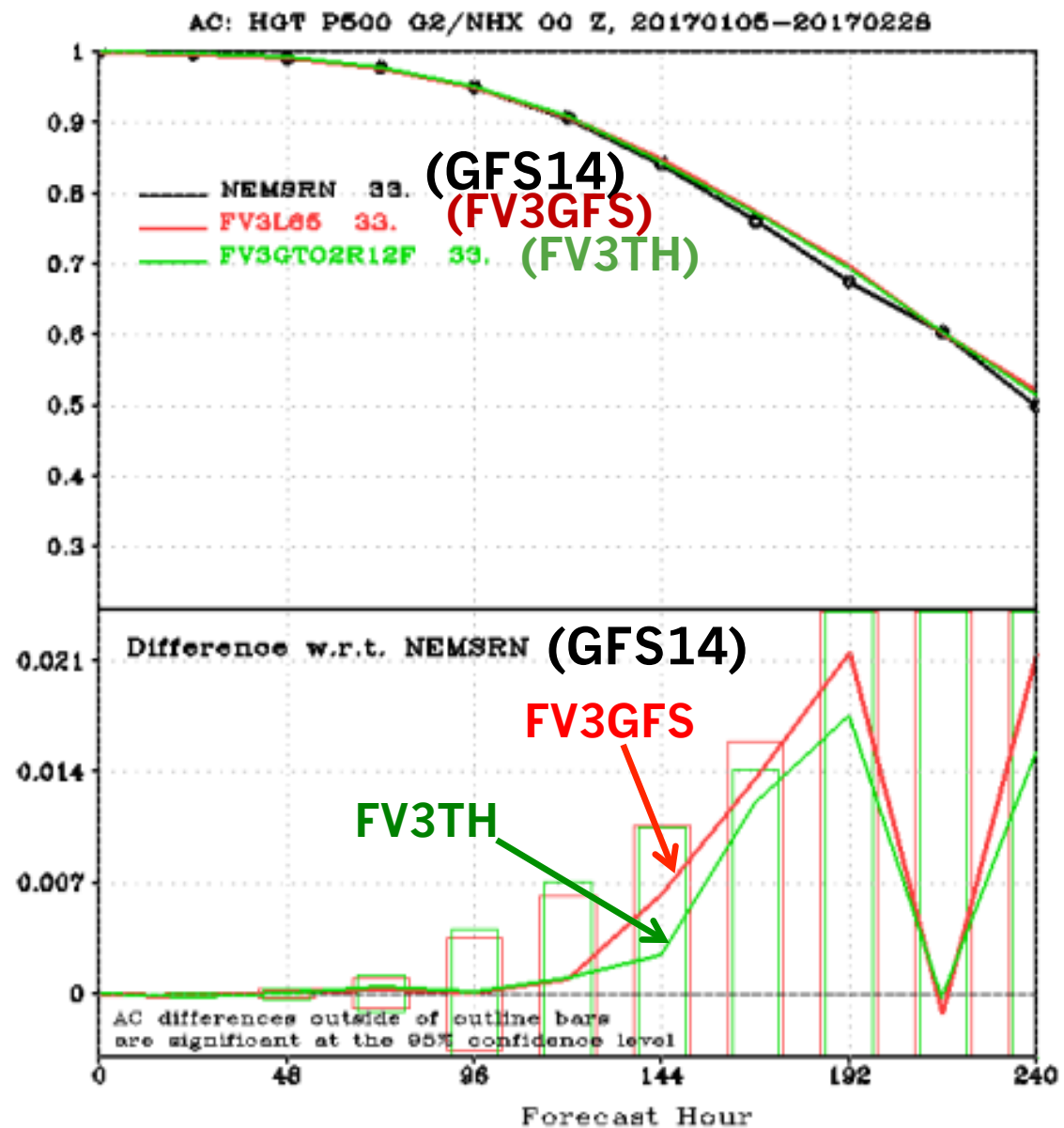
FV3TH (104.0,93.49)
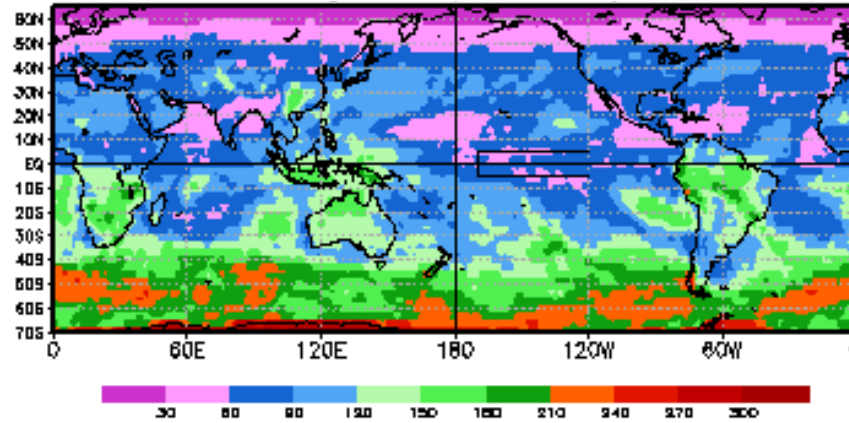
Global mean   Tropical mean

CERES Observations (102.8,93.72)   FV3TH-CERES (1.203, -0.23)
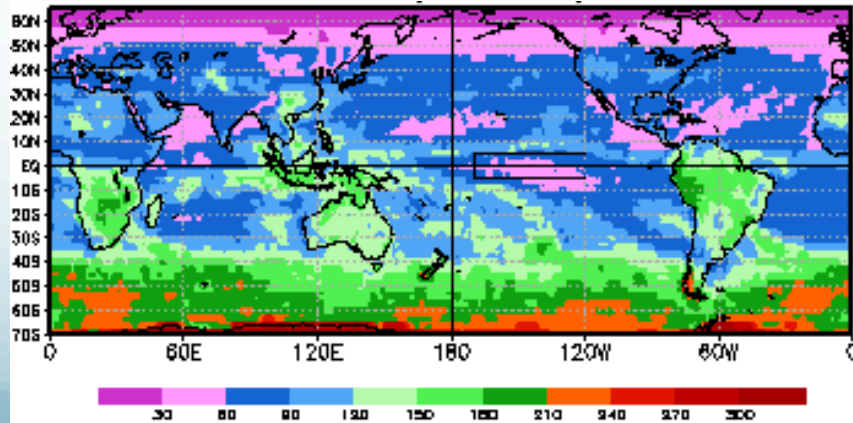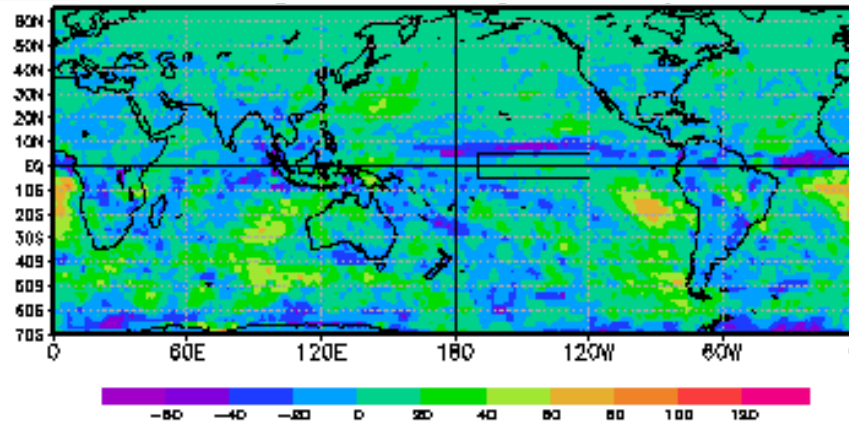
500 hPa Height AC

Summary of Winter Experiment

1. FV3TH generated significantly better USW at the TOA than the FV3GFS.
2. FV3GFS and FV3TH produced significantly better precipitation ETS score than the operational GFS.
3. FV3GFS and FV3TH produced better 500 hPa height AC scores.

Comparison of MPs in the FV3GFS

1. **Experiments:**
   - **GFDL:**   FV3GFS with GFDL MP (current parallel, used as control) replacing Zhao and Carr MP.
   - **THOM**: FV3GFS with Thompson MP replacing Zhao & Carr MP. FV3TH plus negative tracer correction is applied. Mass conservation is ensured. All tracers are mixing by PBL scheme including rain, snow and graupel.
   - **MG2:**   FV3GFS with MG2 replacing Zhao & Carr MP
2. Experiment period: 20160101 to 20170629 every 5 days
3. Forecast only. ICs were converted from ICS of the operational GFS.

Total Cloud Cover
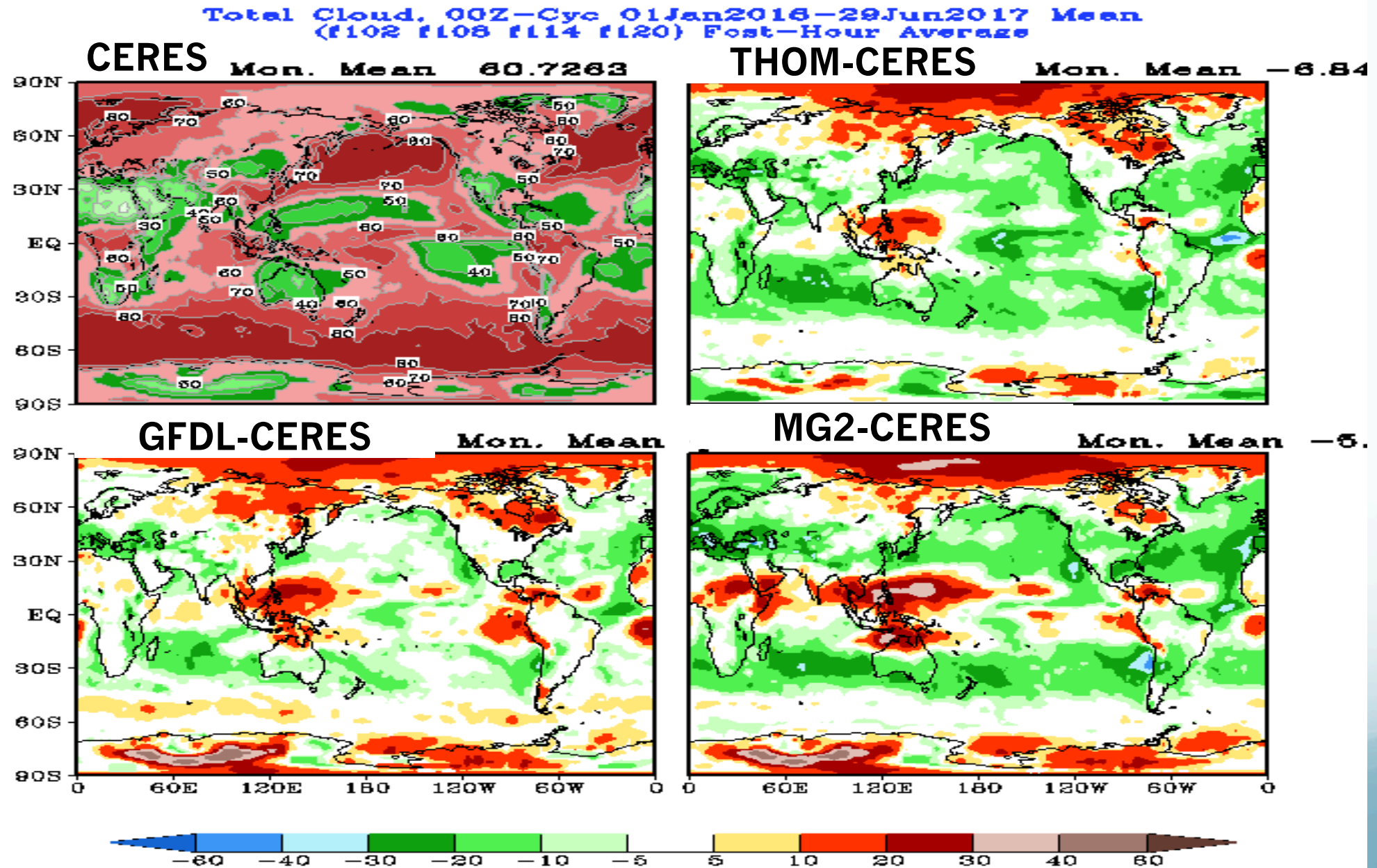
Low Cloud Cover

Low Cloud, 00Z-Cyc 01Jan2016-29Jun2017 Mean
(f102 f108 f114 f120) Fost-Hour Average

CERES — Mon. Mean 26.2831
THOM-CERES — Mon. Mean 2.320
GFDL-CERES — Mon. Mean
MG2-CERES — Mon. Mean 3.0

Middle Cloud Cover

Middle Cloud, 00Z-Cyc 01Jan2016-29Jun2017 Mean
(f102 f108 f114 f120) Fcst-Hour Average

CERES — Mon. Mean 17.0465

THOM-CERES — Mean 2.873

GFDL-CERES — Mon. Mean

MG2-CERES — Mon. Mean −4.
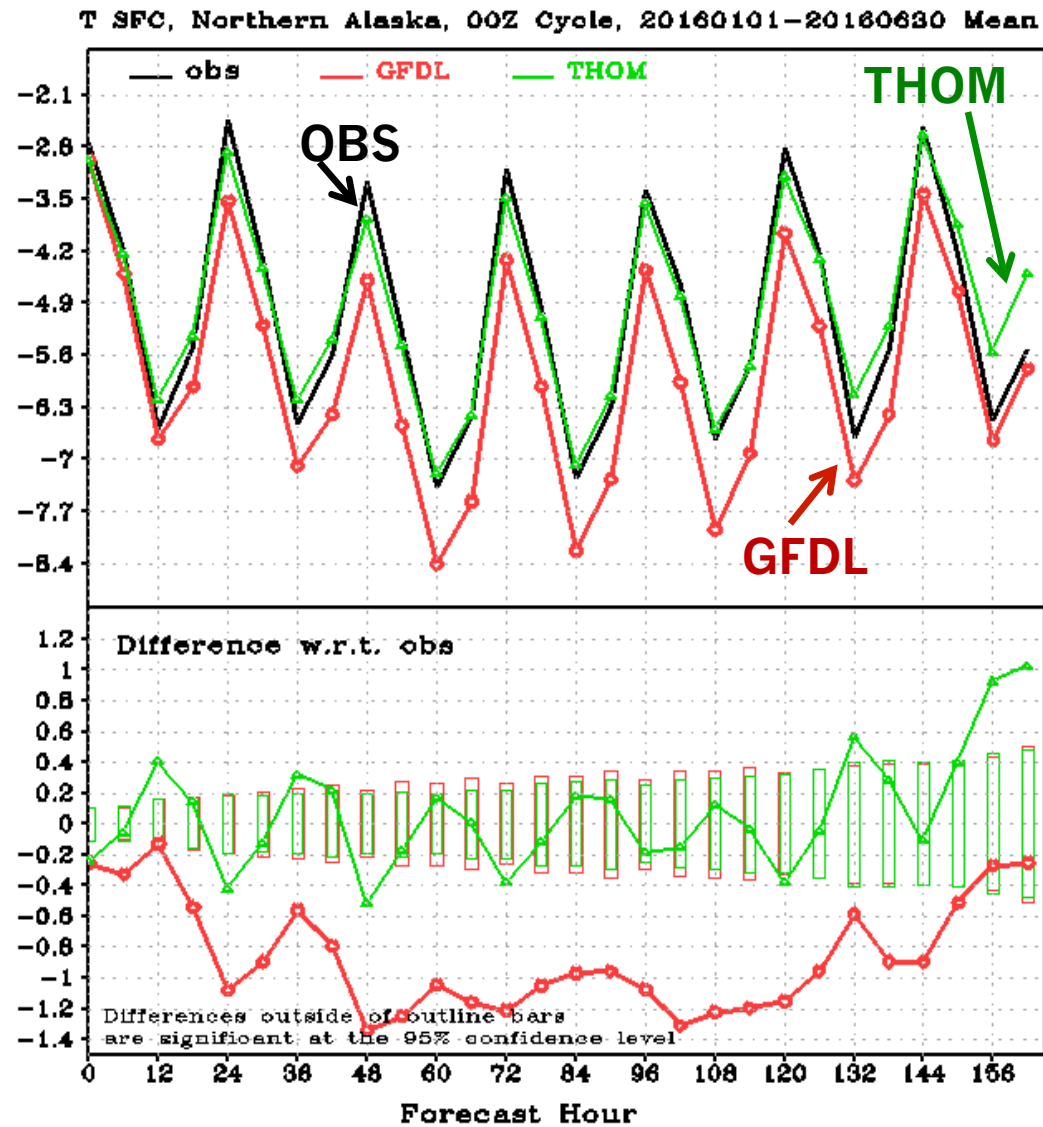
14
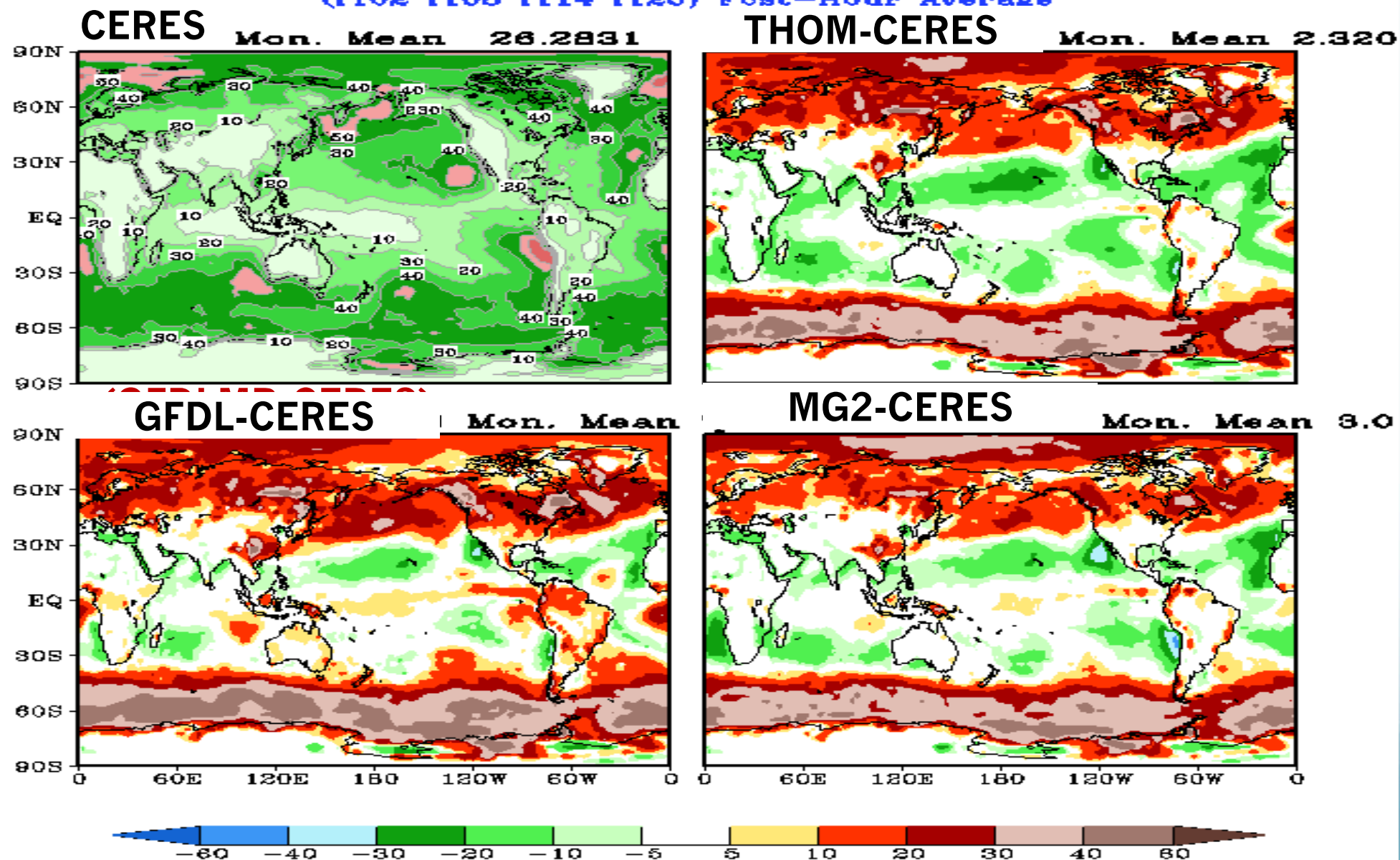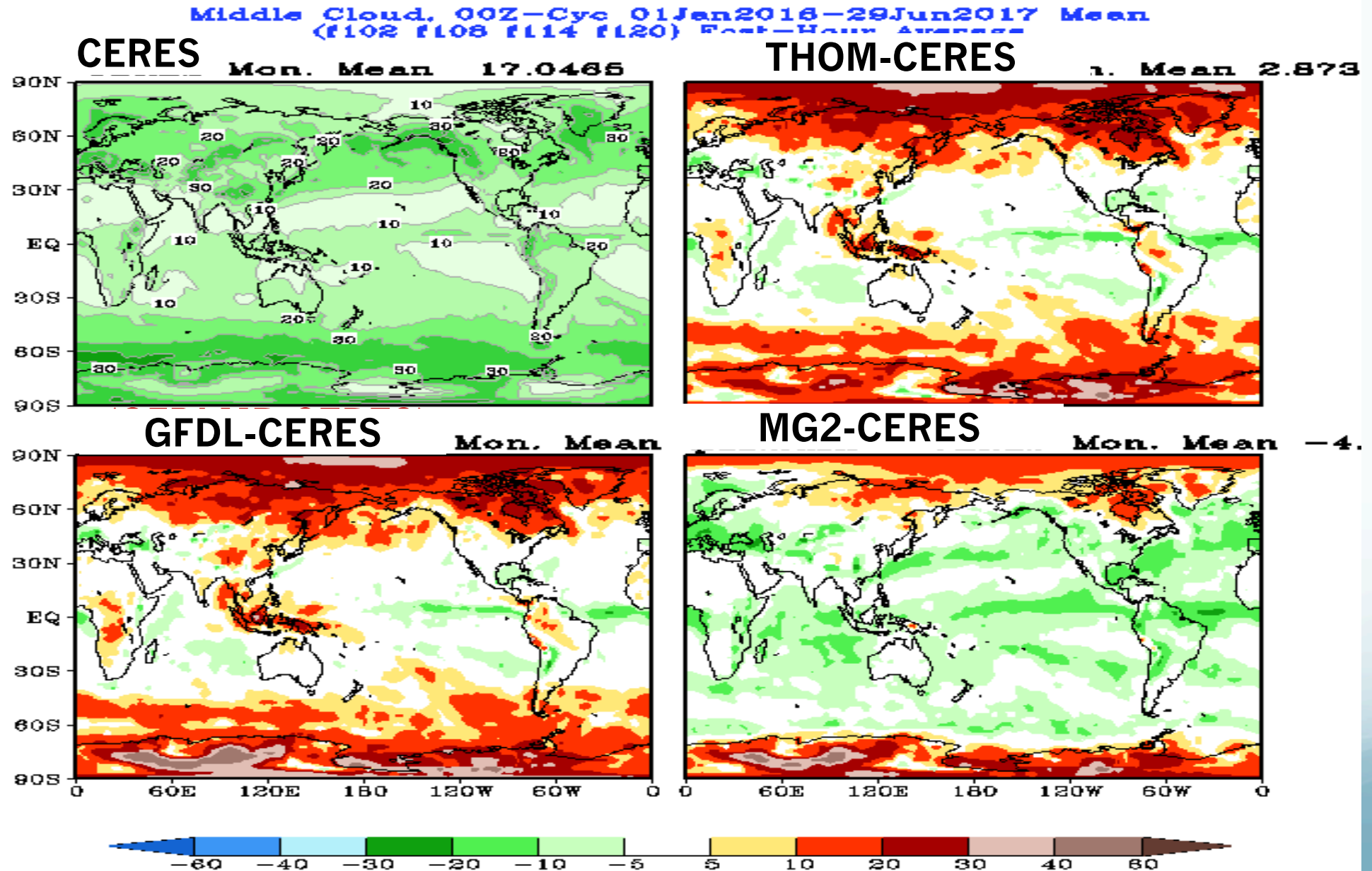
High Cloud Cover

TOA OLR

TOA Up LW, 00Z-Cyc 01Jan2016-29Jun2017 Mean
(f102 f108 f114 f120)

CERES — Mon. Mean 236.6851

THOM-CERES — Mon. Mean 8.088

GFDL-CERES — Mon. Mean

MG2-CERES — Mon. Mean 14.

16
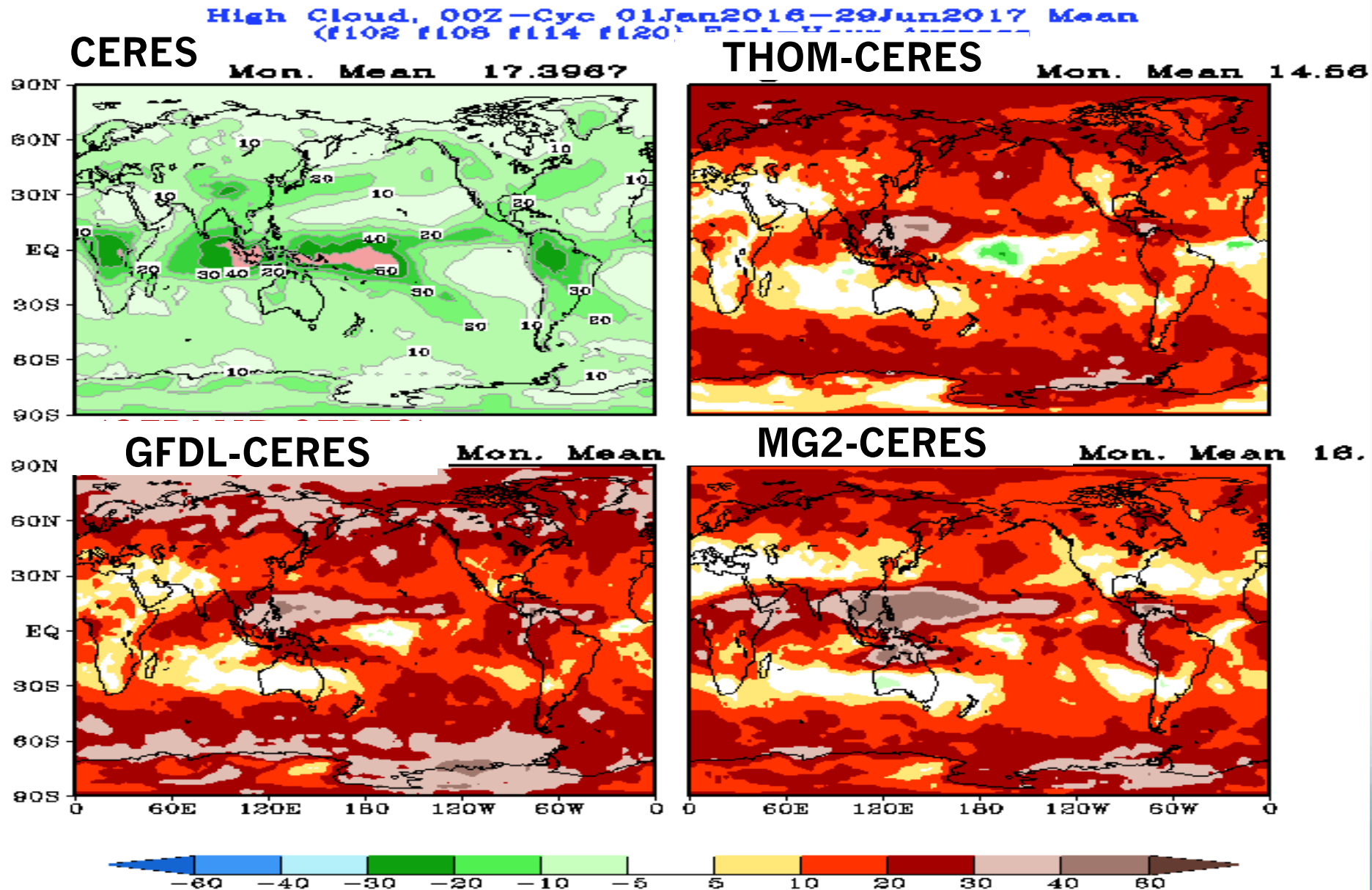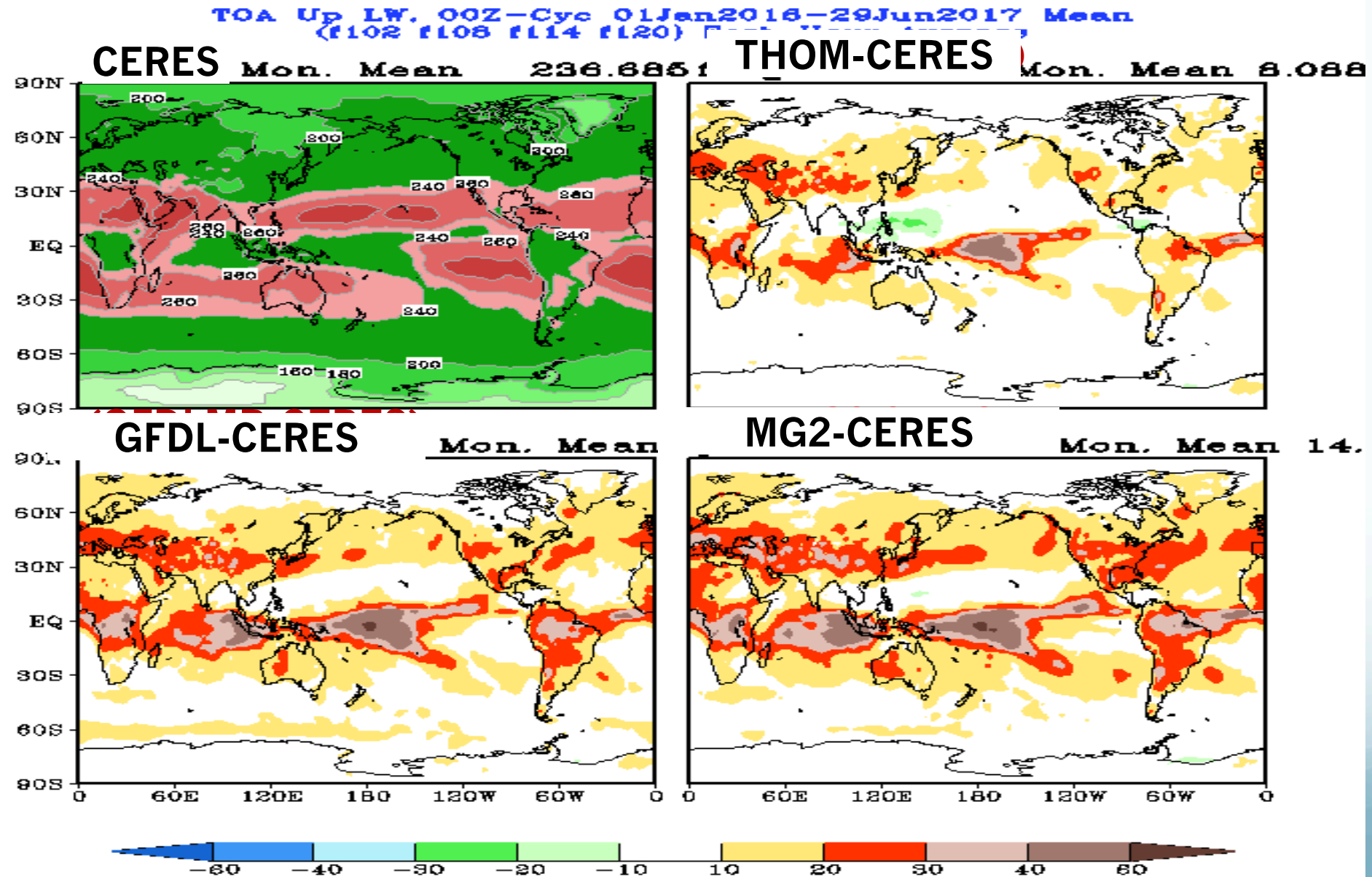
TOA UP SW
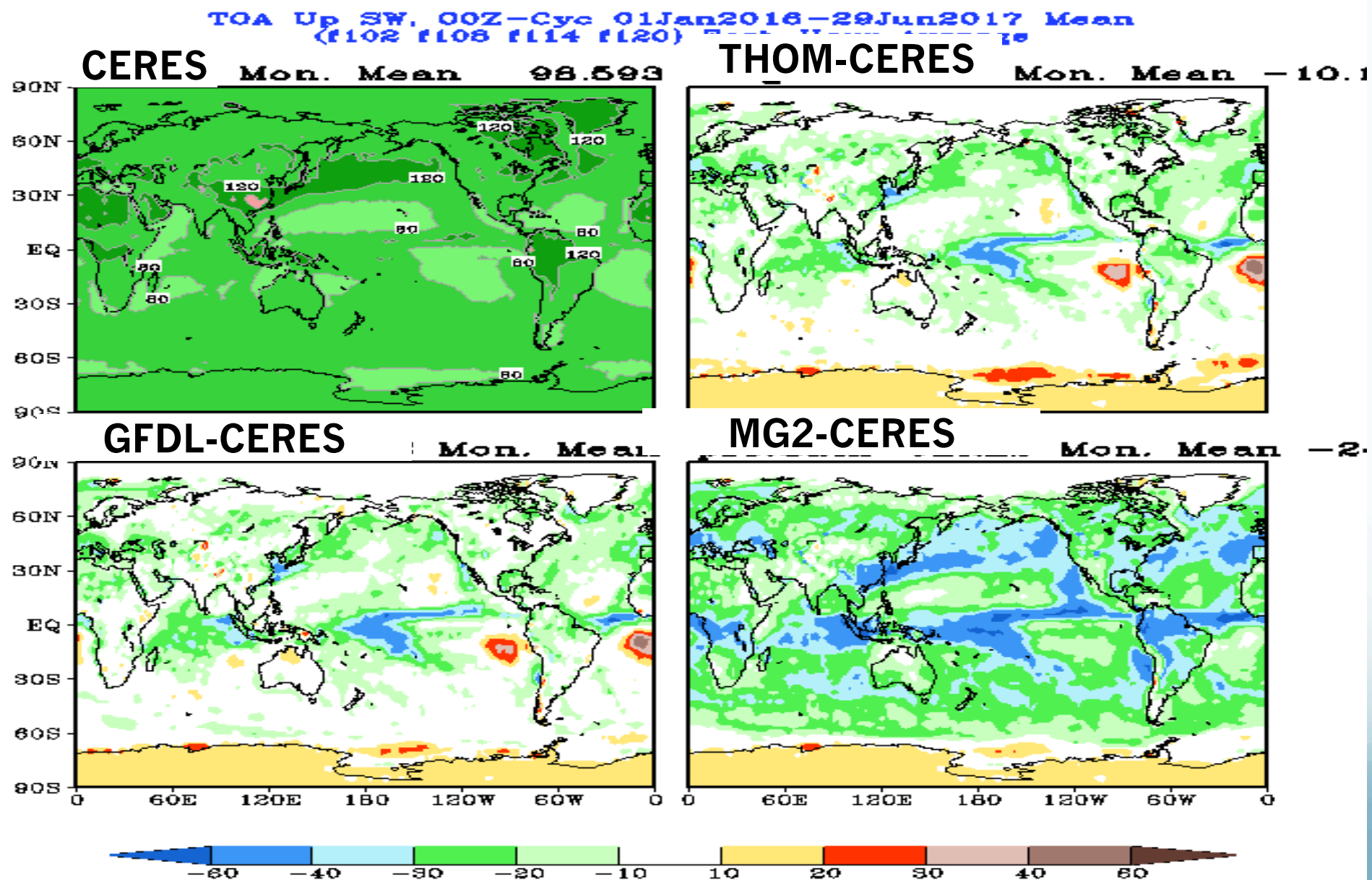
TOA Up SW, 00Z-Cyc 01Jan2016-29Jun2017 Mean
(f102 f108 f114 f120)

CERES Mon. Mean 98.593

THOM-CERES Mon. Mean -10.1

GFDL-CERES Mon. Mean

MG2-CERES Mon. Mean -2.

17

Surface Down SW
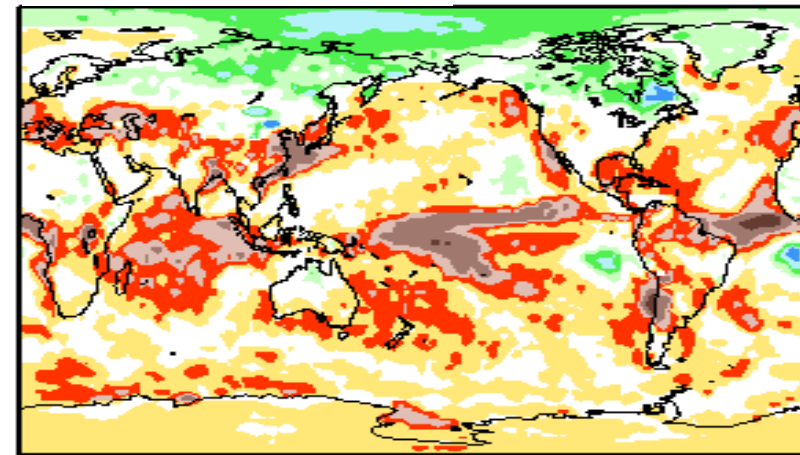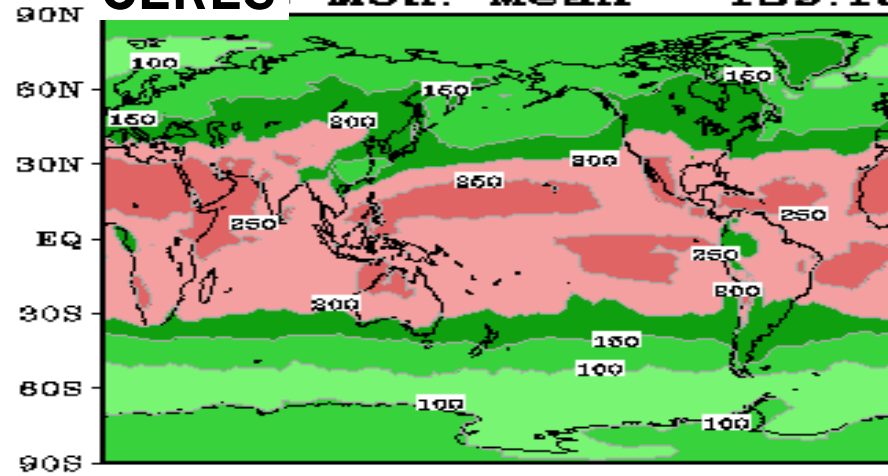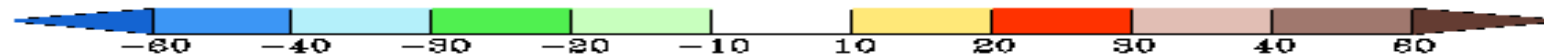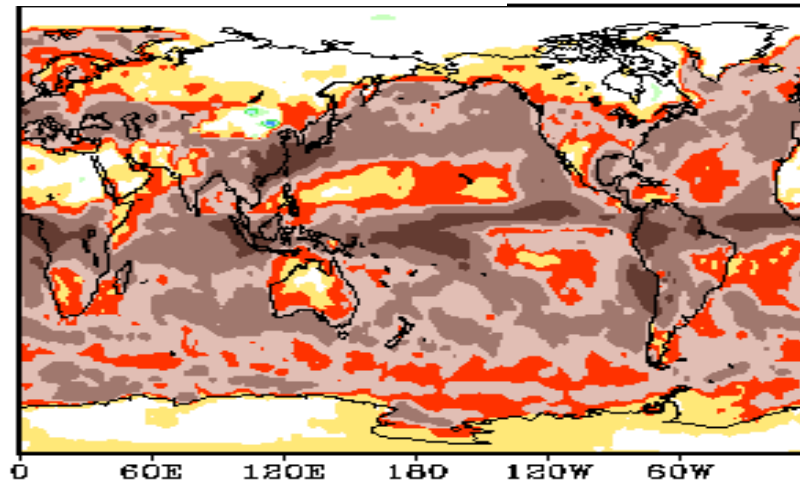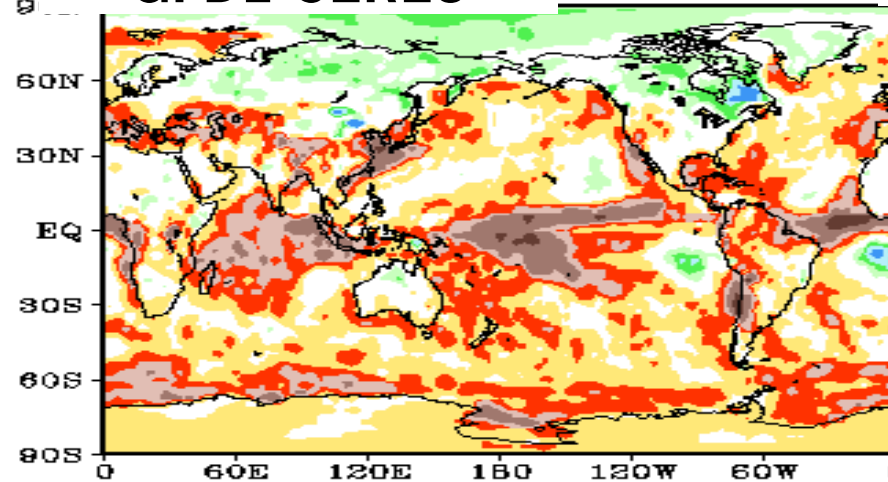
CONUS Precipitation Equitable Threat Score
01Jan2016–29Jun2017 00Z Cycle
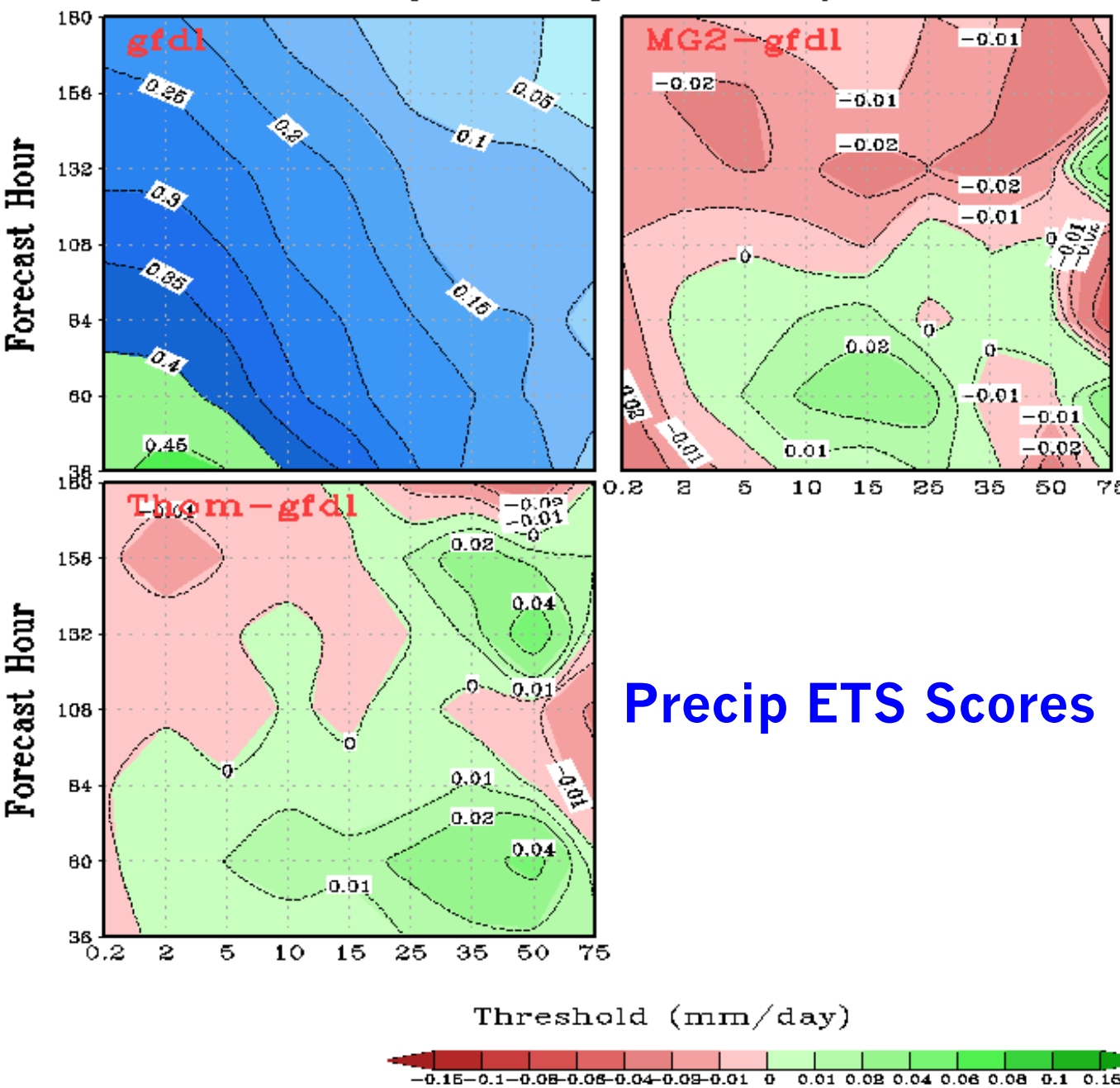
CONUS Precipitation BIAS Score
01Jan2016–29Jun2017 00Z Cycle

Precip ETS Scores

Precip Bias Scores

Threshold (mm/day)

Threshold (mm/day)
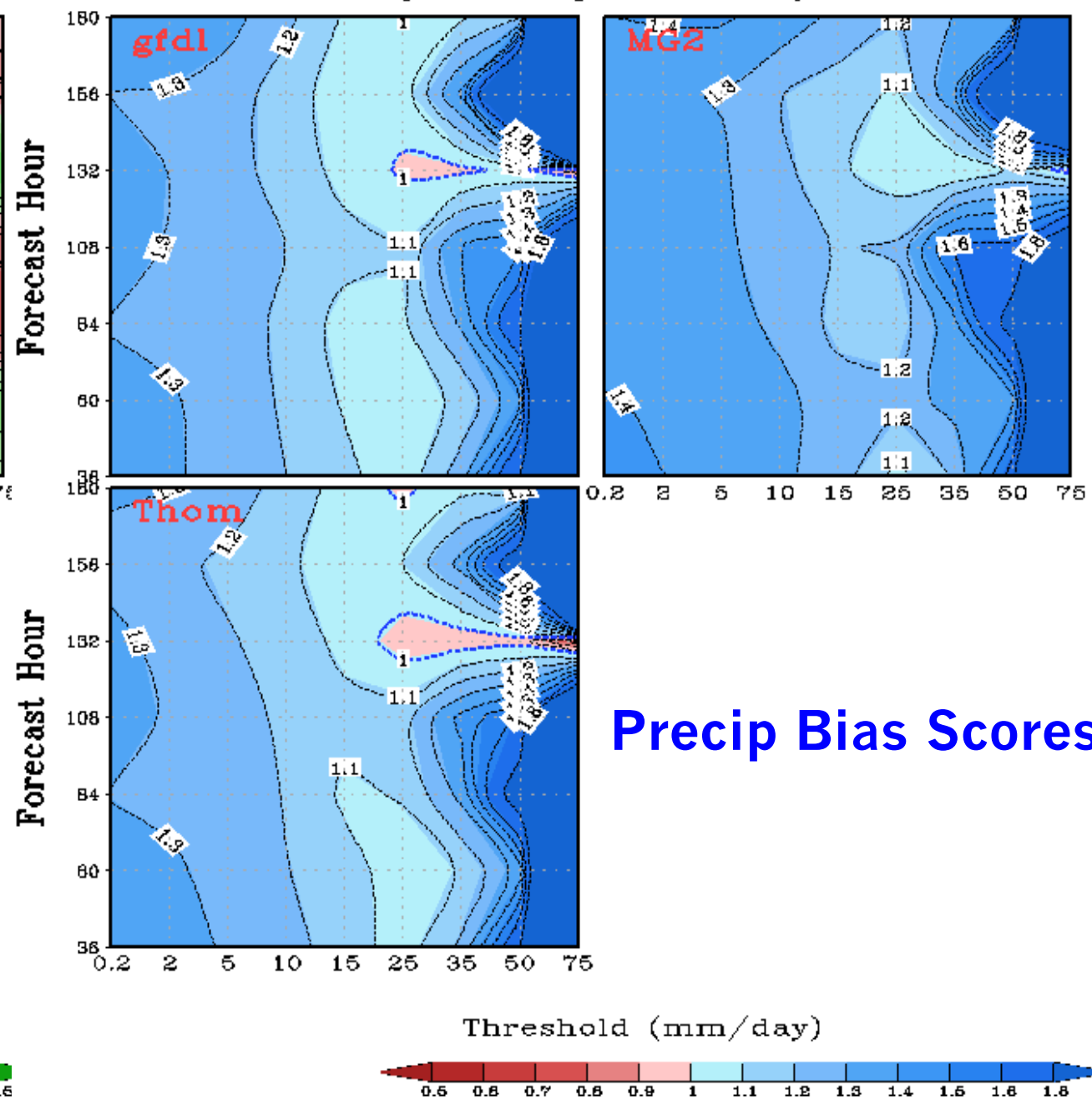
Precipitation ETS and Bias scores-FH36-60

CONUS Precip Skill Scores, f36–f60, 01jan2016–29jun2017 00Z Cycle

Differences outside of the hollow bars are 95% significant based on 10000 Monte Carlo Tests
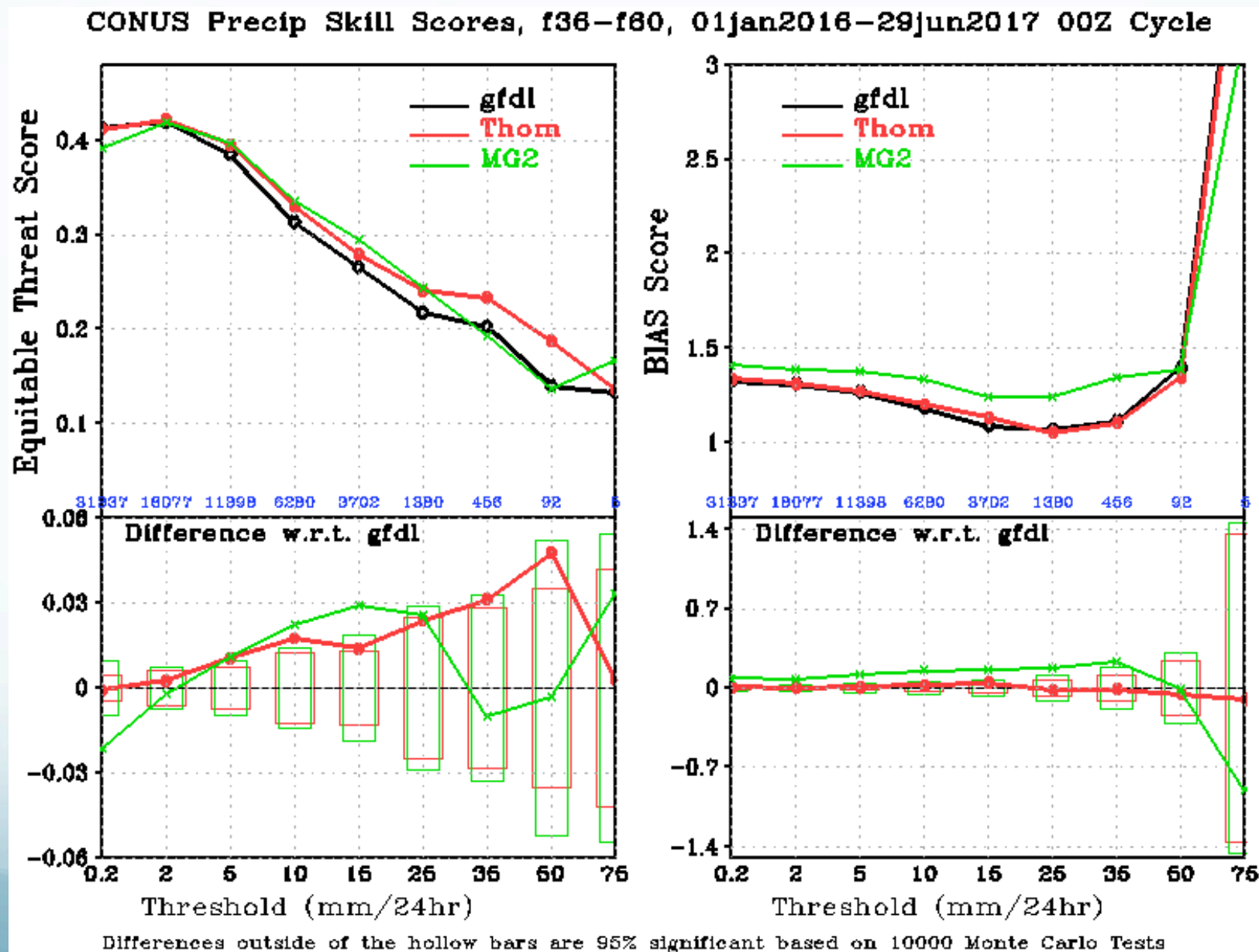
500 hPa Height AC at FH120
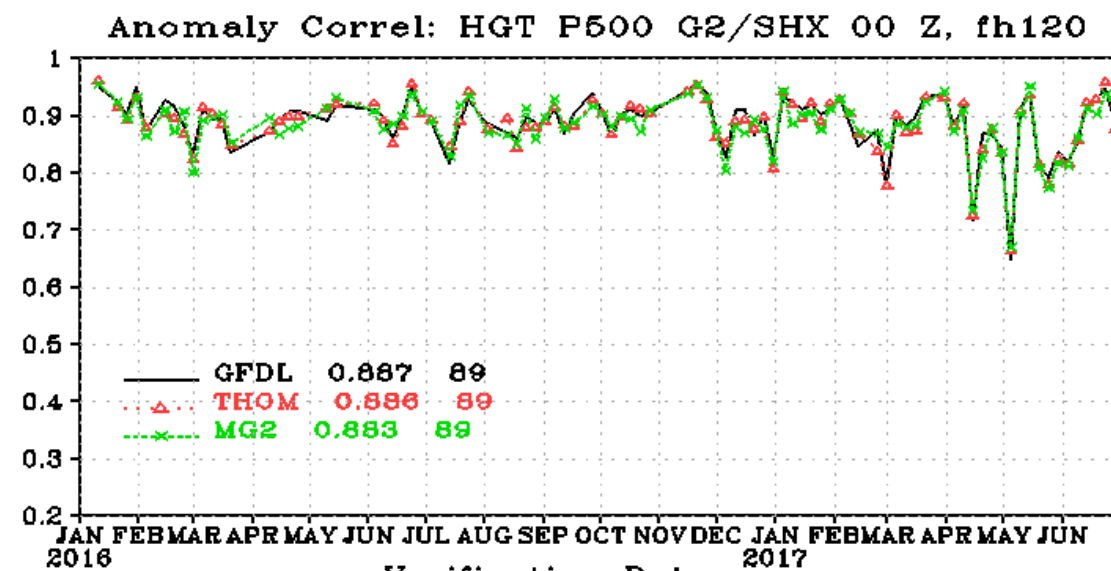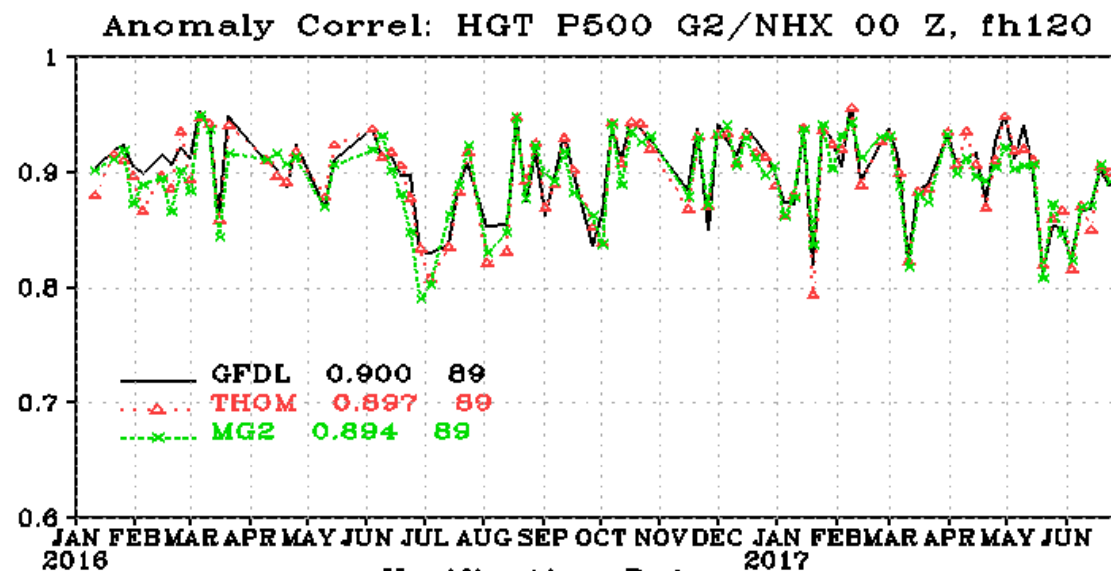
Temperature Cross Section

Temp (K), 00Z-Cyc 01Jan2016-29Jun2017 Mean
Fost-Hour #120
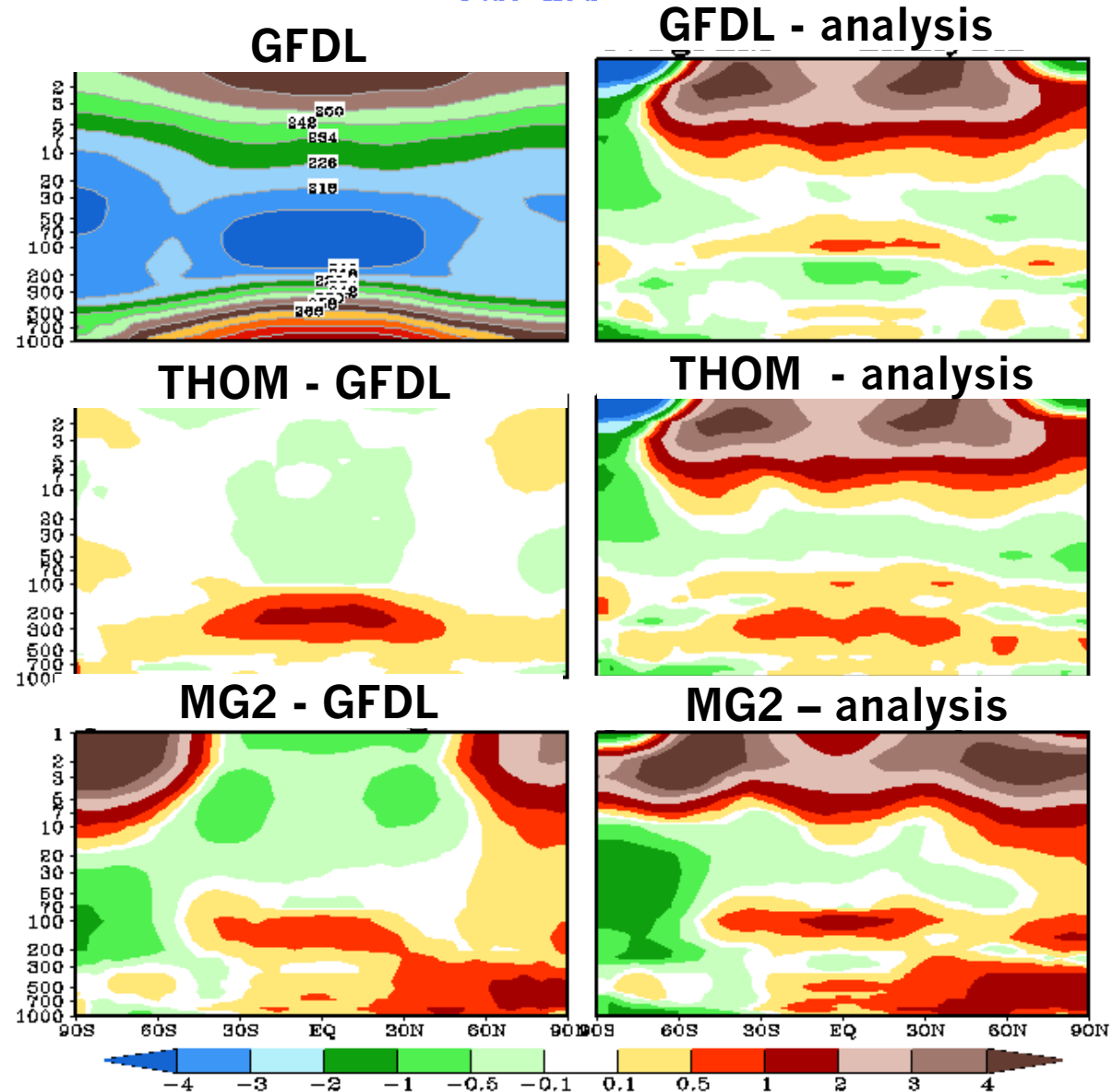
GFDL

GFDL - analysis

THOM - GFDL

THOM - analysis

MG2 - GFDL

MG2 – analysis

22
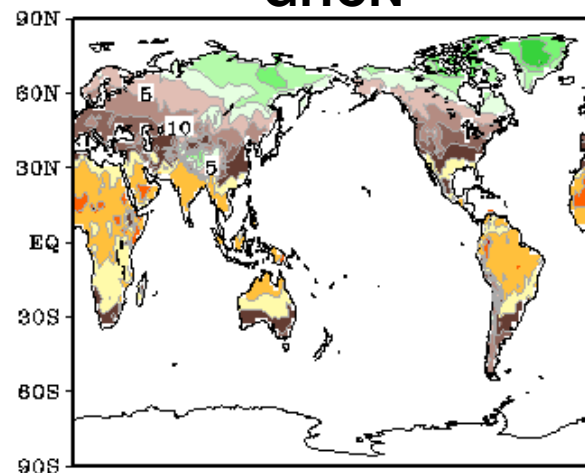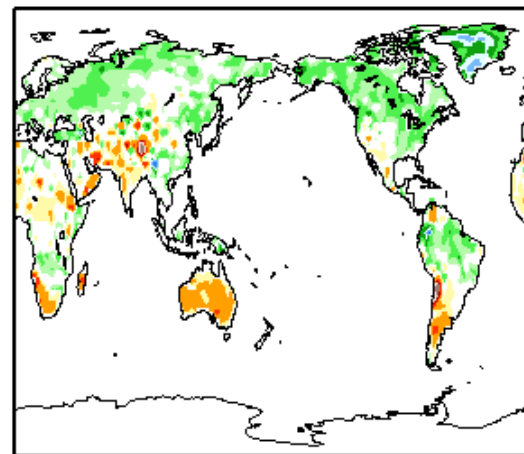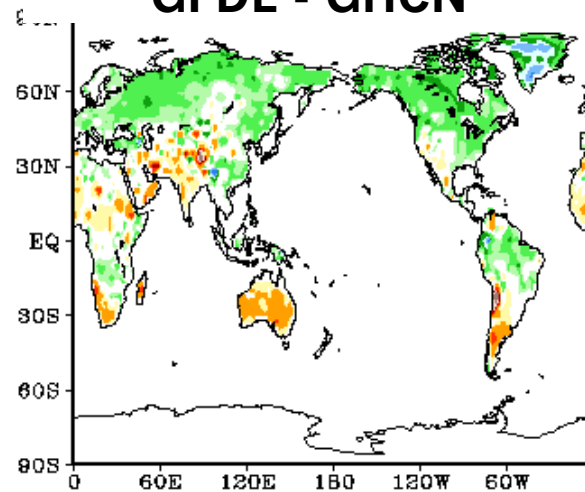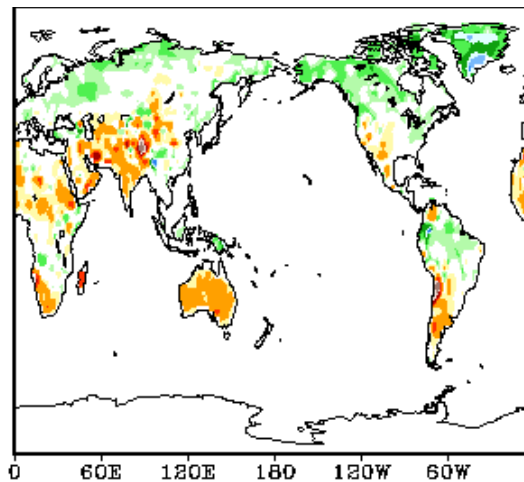
2M Temperature

SFC Temperature Bias and RMSE
in Northern Alaska
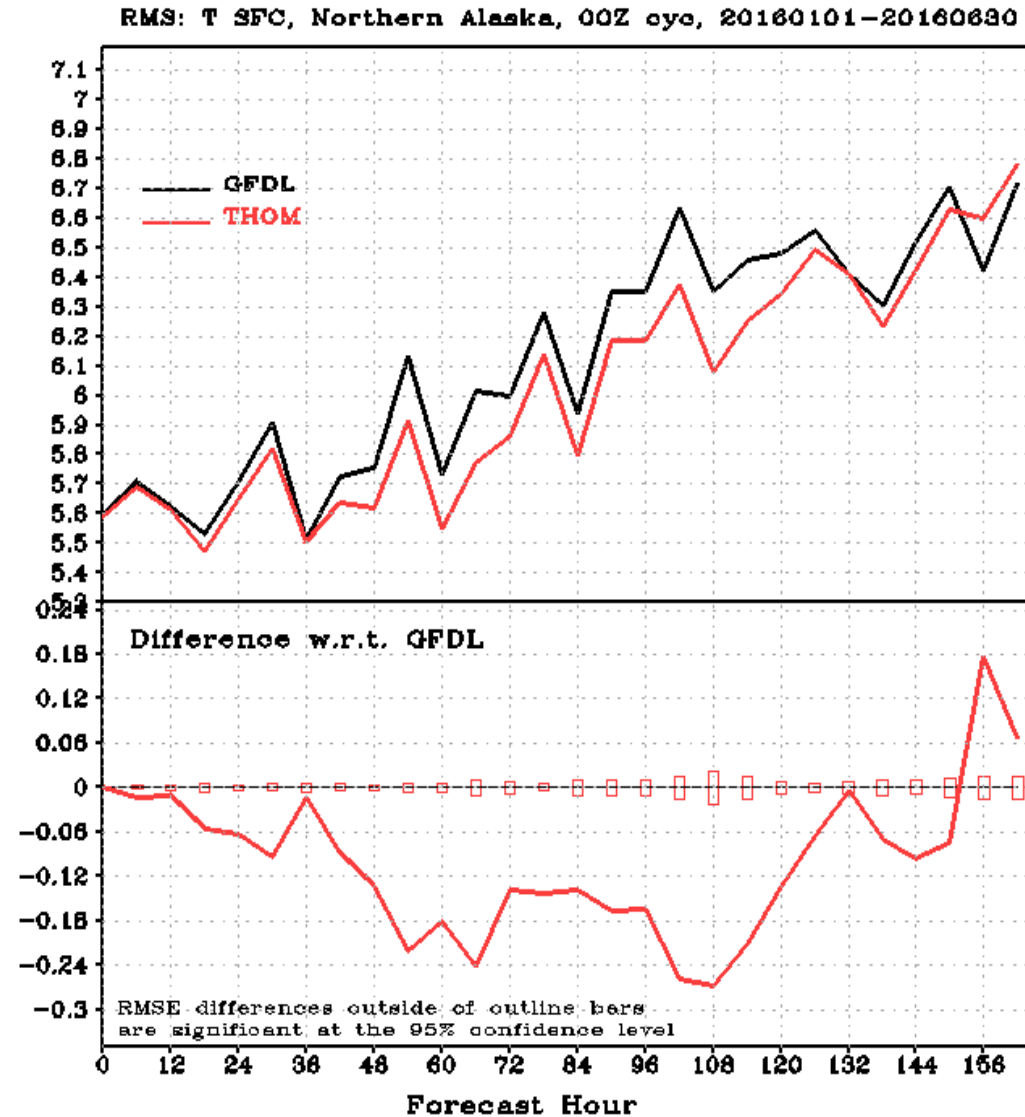
SFC Temperature Bias and RMSE
in Southern Alaska
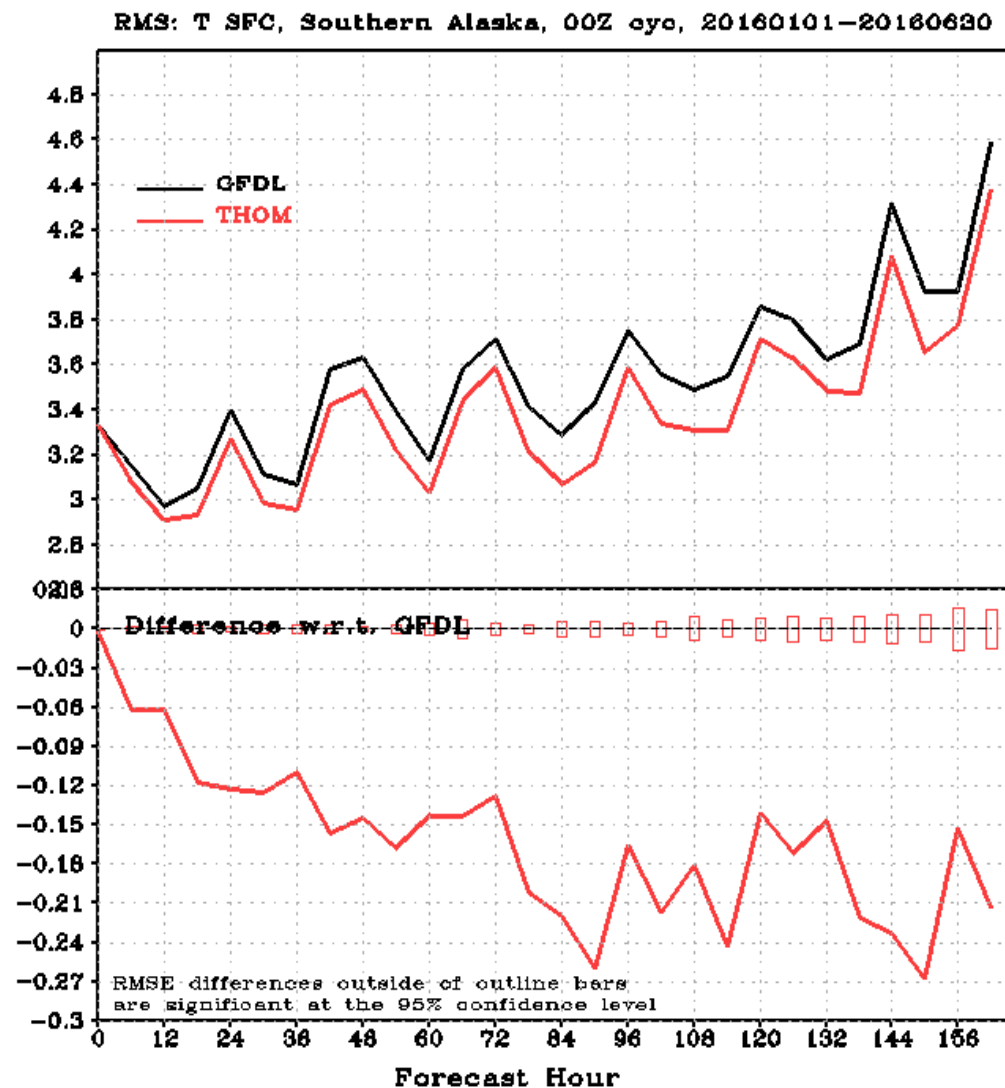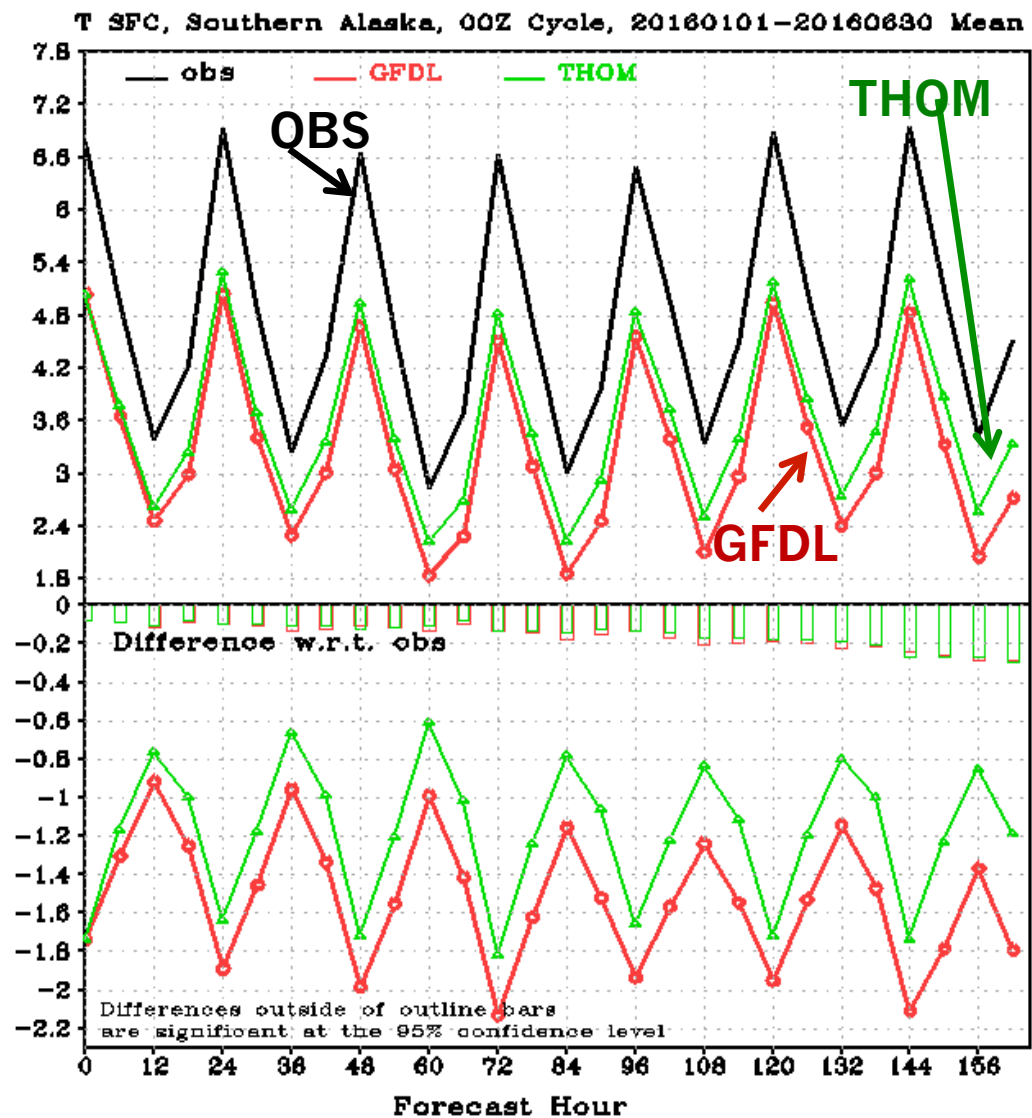
SFC Wind Bias and RMSE in Northern Alaska
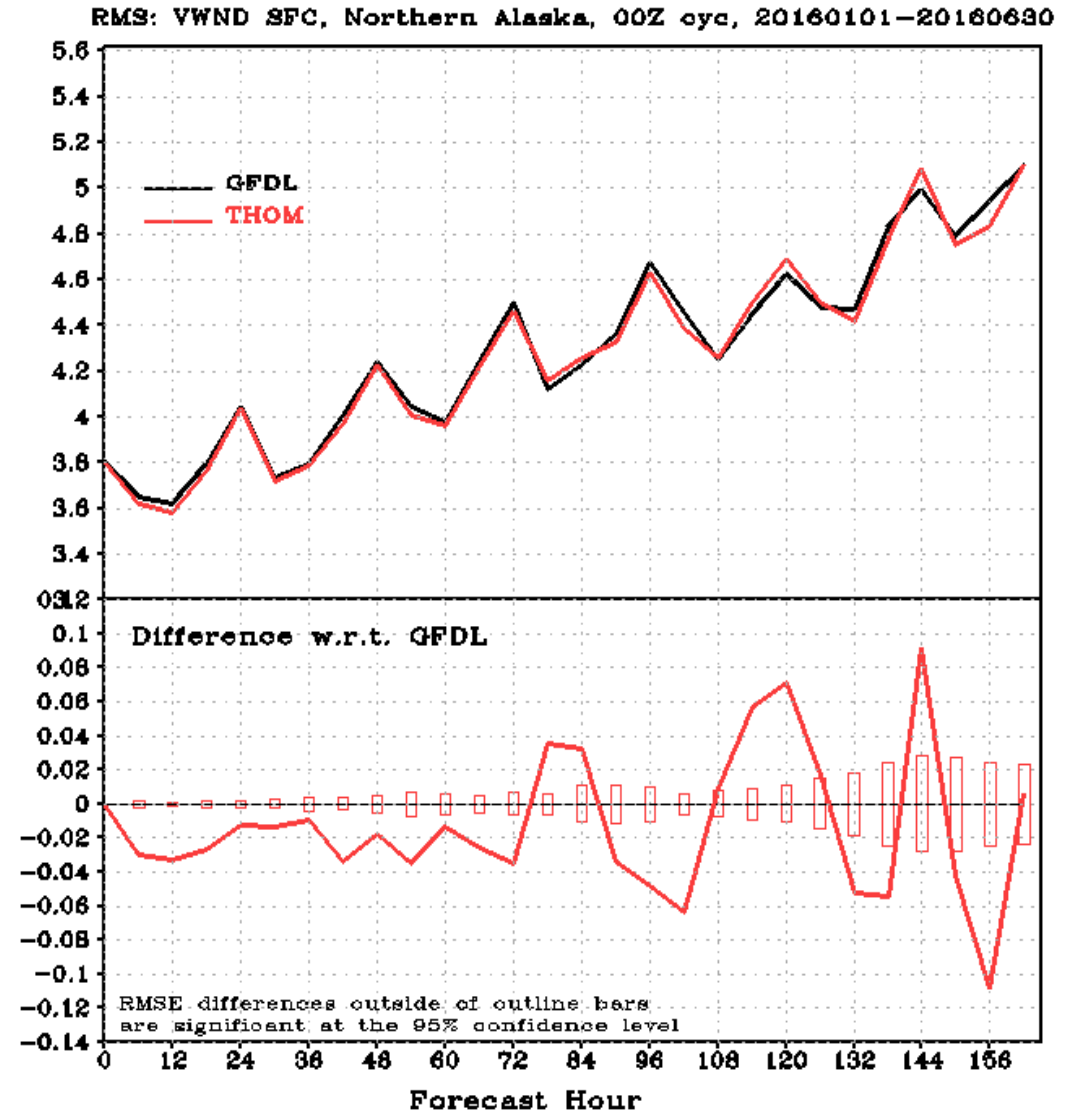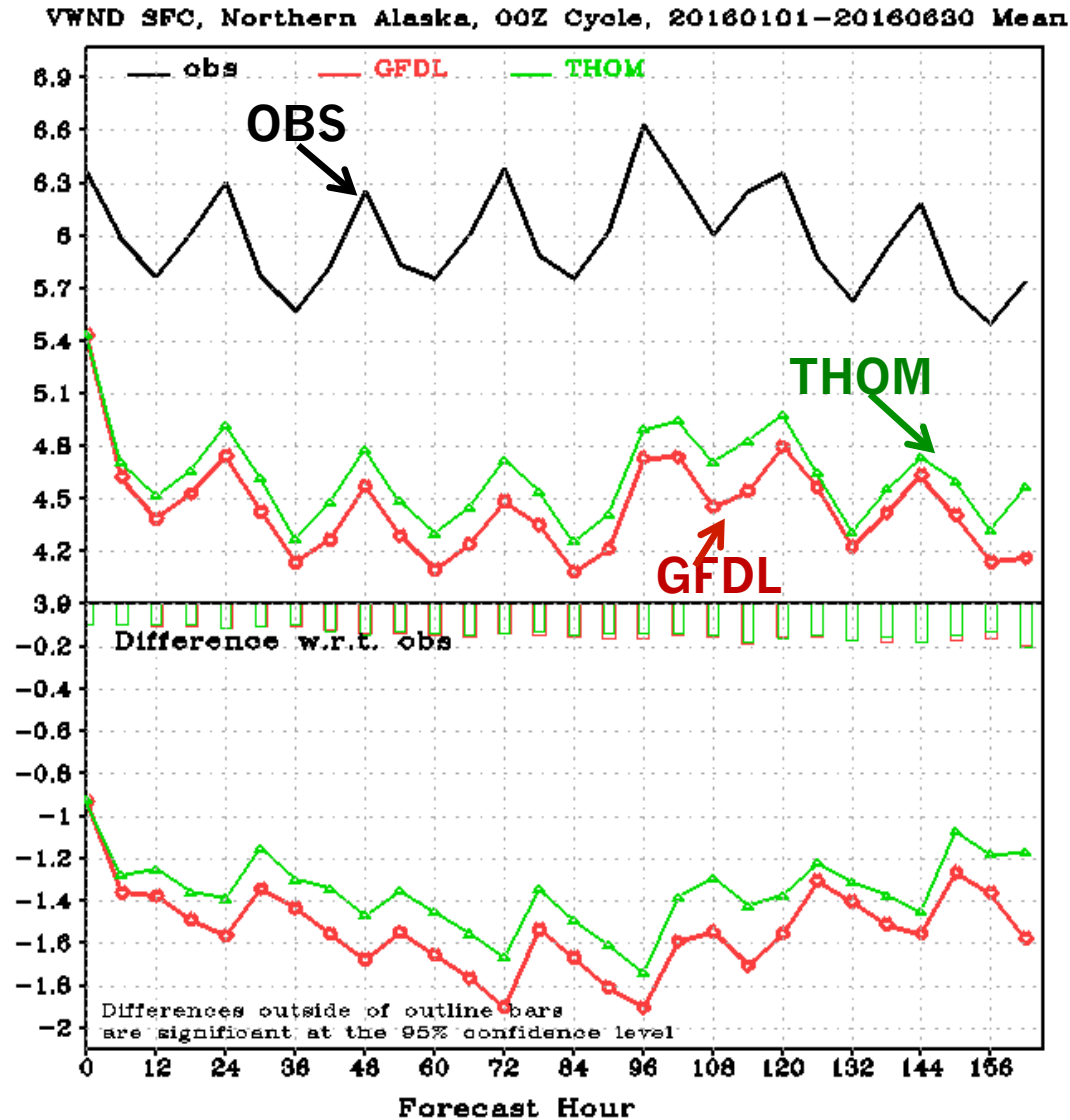
SFC Dew Point Bias and RMSE in Northern Alaska
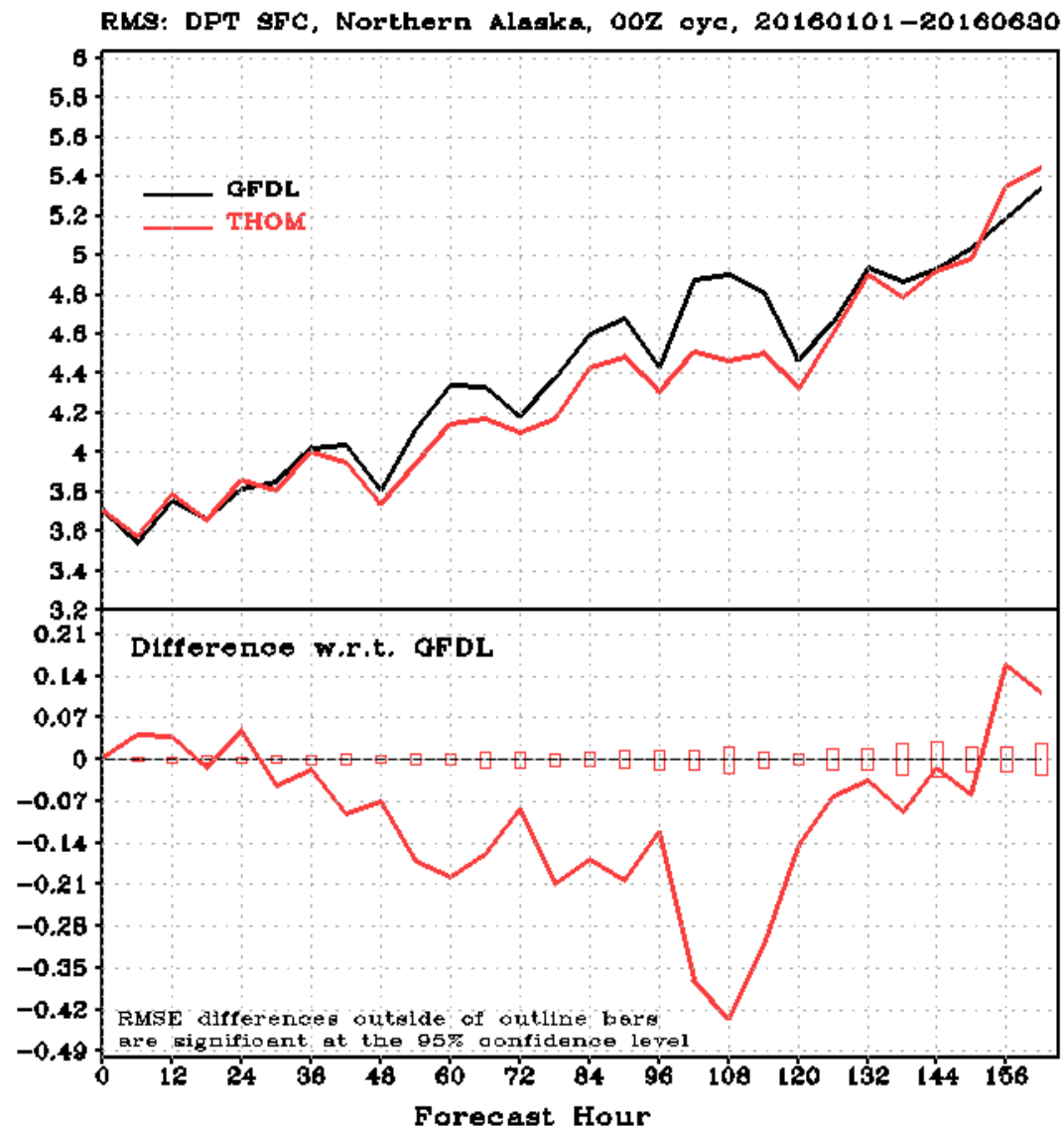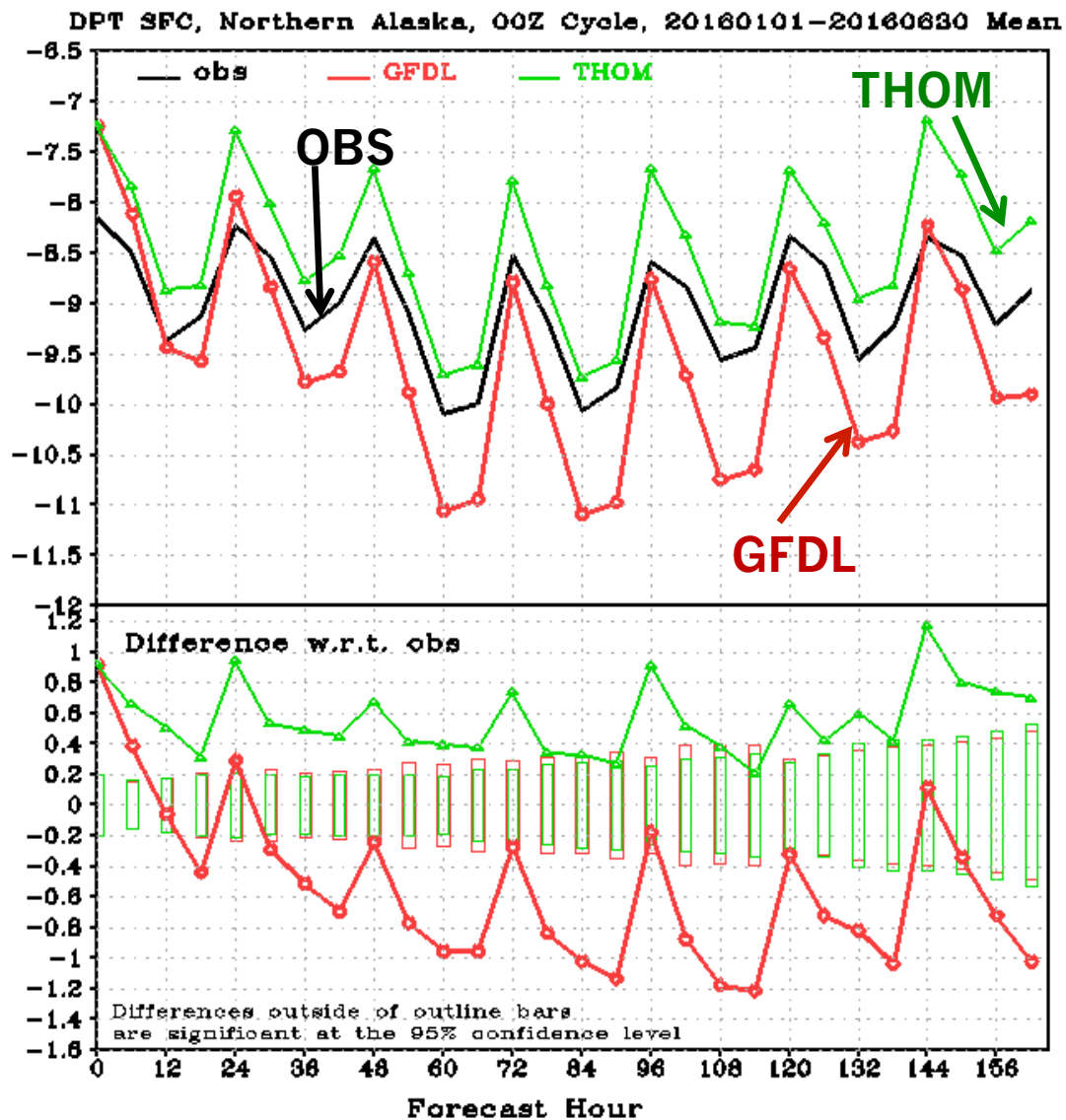
Summary

1. Compared with CERES, FV3GFS with all MPs produced too much OLR at TOA (THOM is closest to CERES), too little outgoing SW radiative flux at TOA (the least with MG2), and too much downward radiative flux at the surface (the most with MG2).
2. The THOM generated overall better precipitation ETS score than the GFDL MP, especially in the first 4 days of forecasts. MG2 also produced better precipitation ETS score in the same period for most range, but worse in the light and most intense precipitation ranges than the GFDLM MP. GFDL MP produced the best precipitation ETS score for the long lead forecast range.
3. GFDL MP and Thompson MP produced comparable 2m temperature forecasts. Over Alaska Thompson MP produced better 2M temperature forecasts.

Backup Slides

Mid-Level and Low-level Cloud Fractions
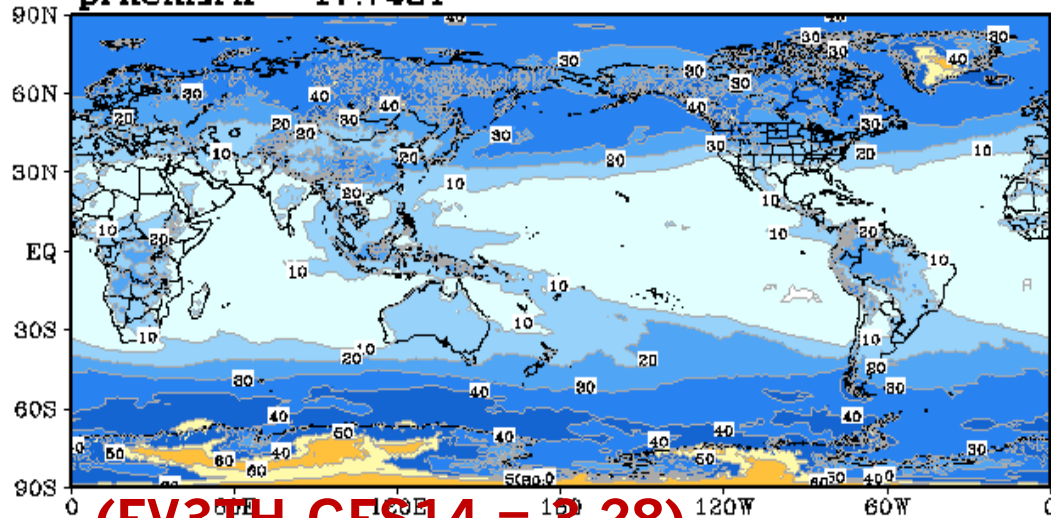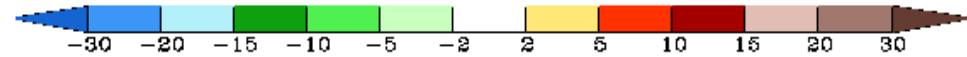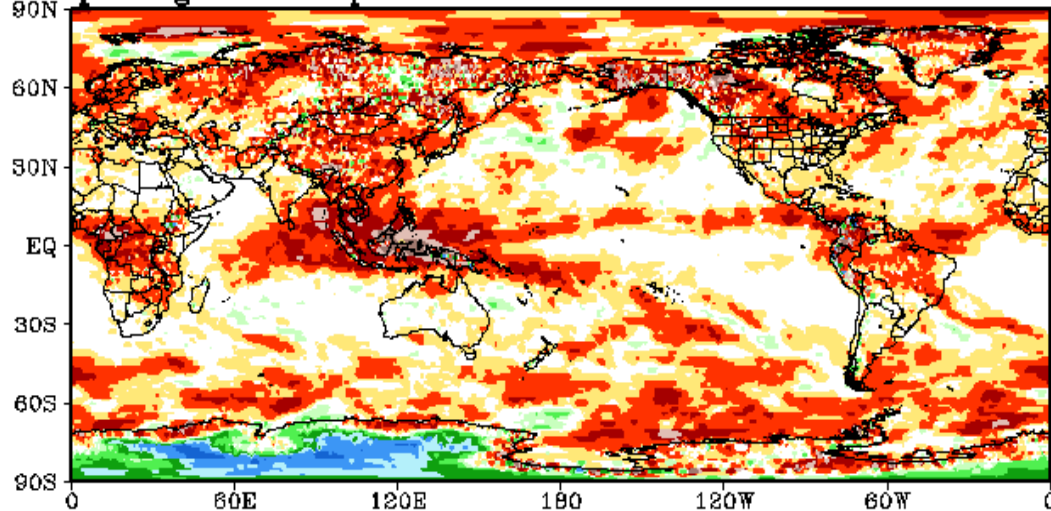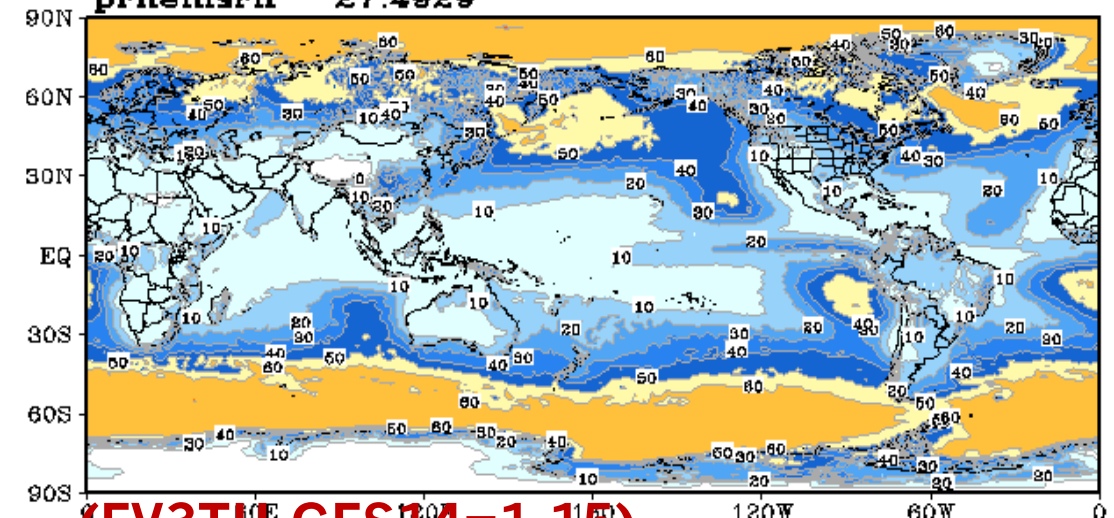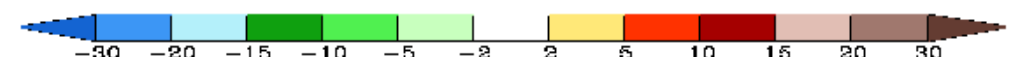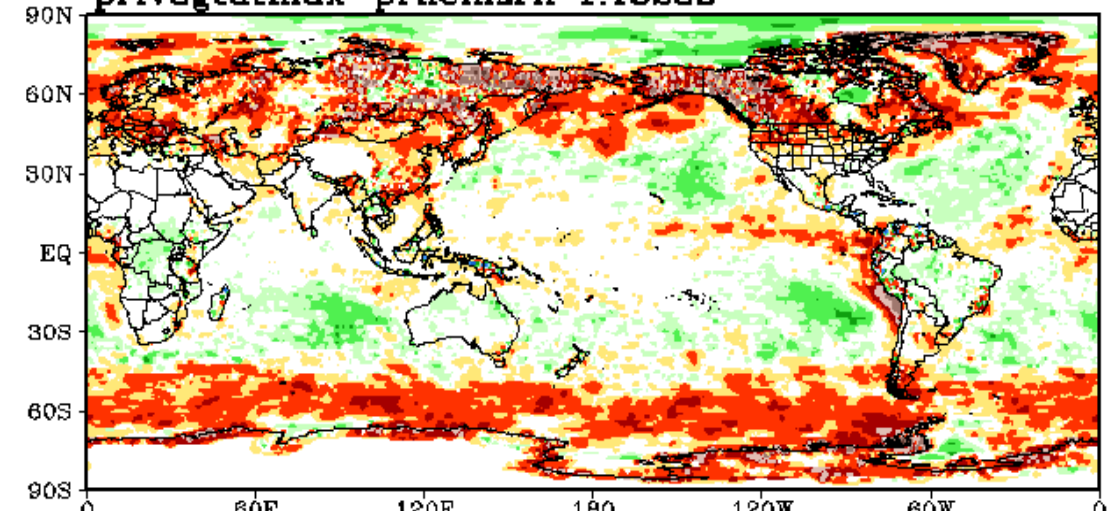
Thompson and GFDLMP precipitation ETS Score

— **20161101-20170629 (50 cases)**

Less than 300 cases
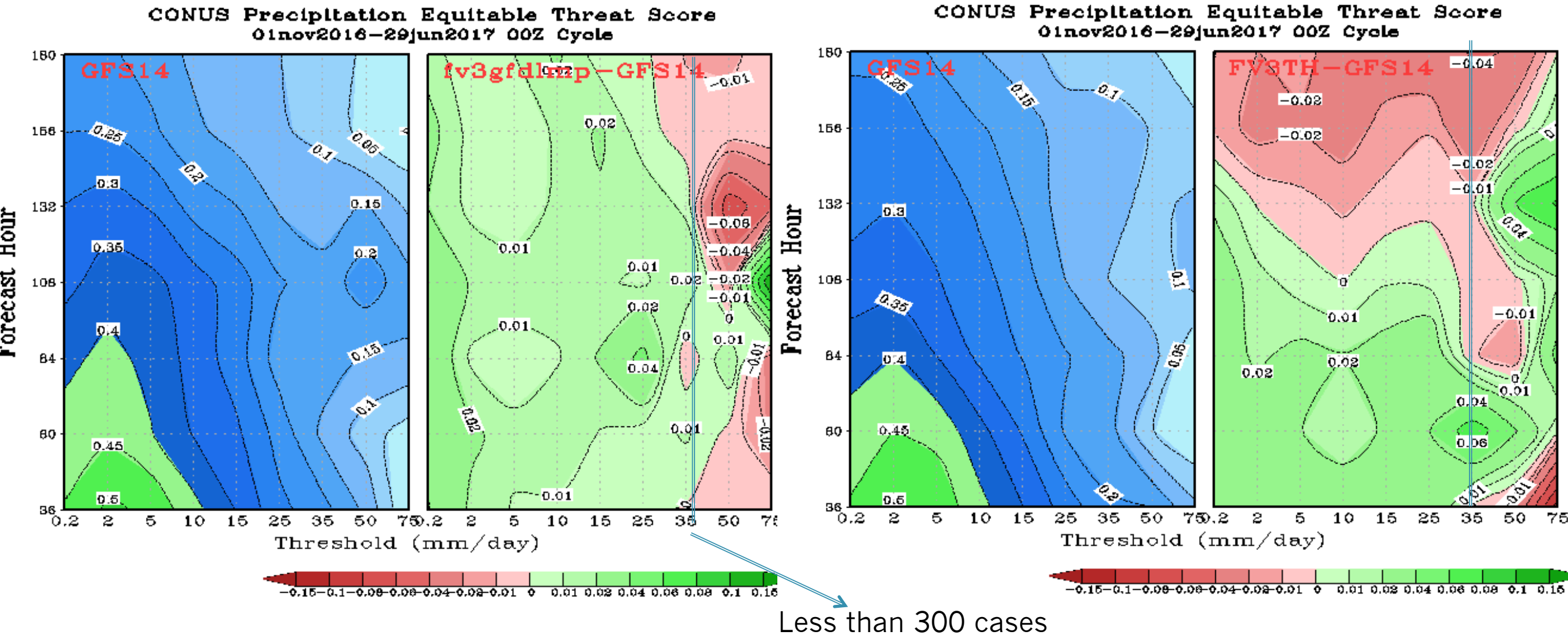
TOA OLR (201611-201701)
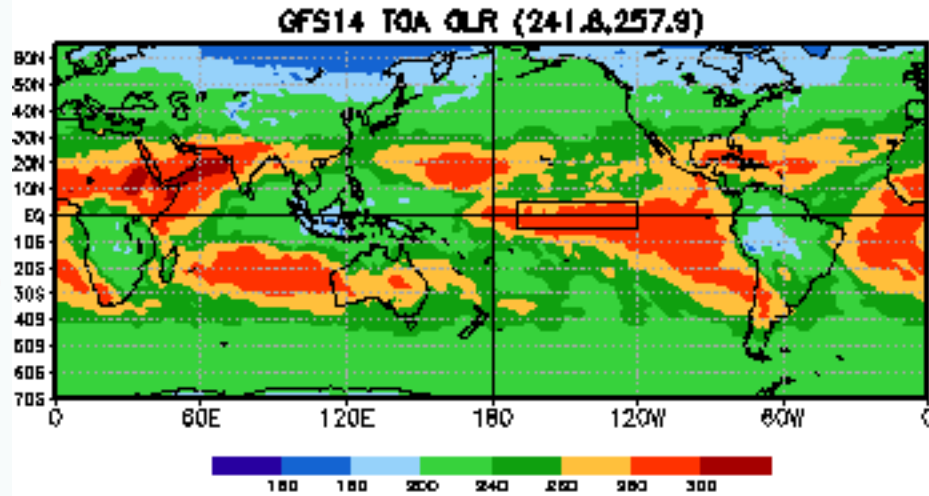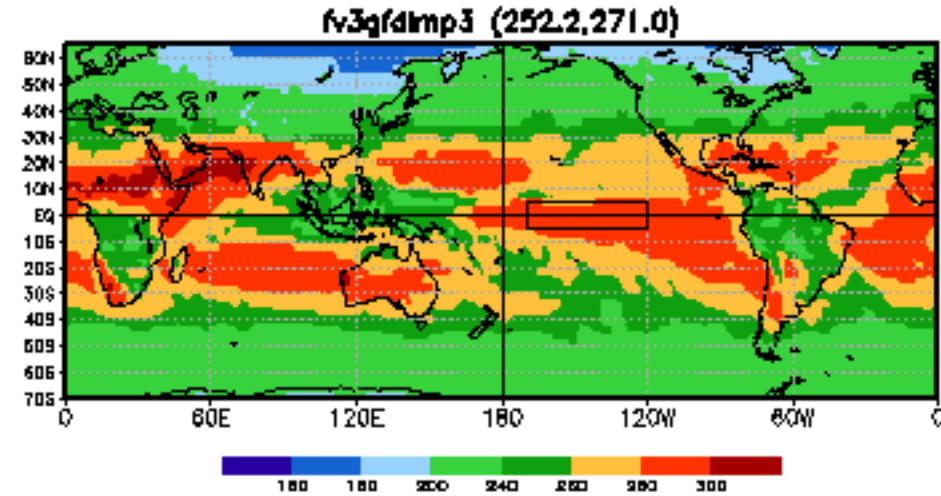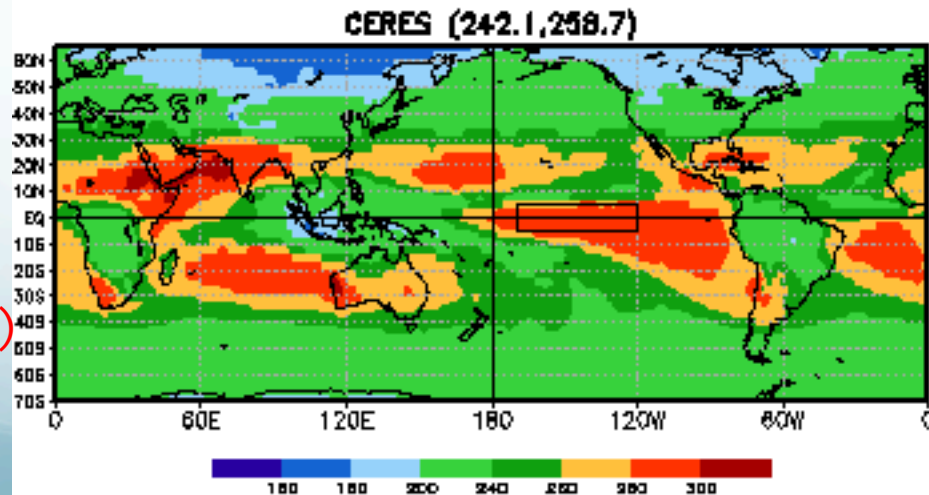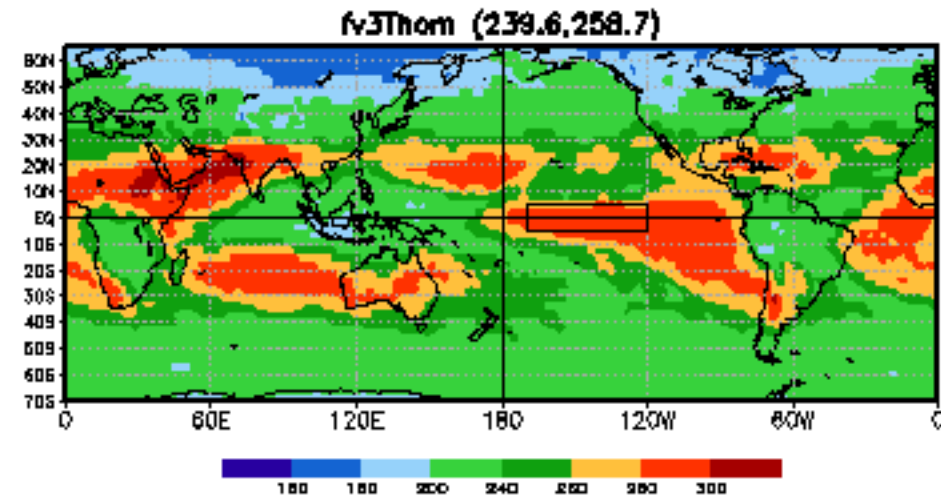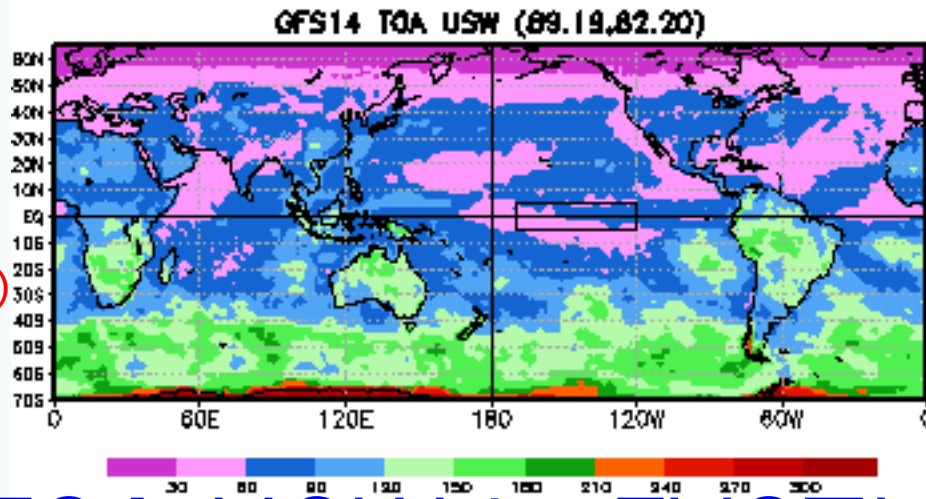
TOA USW (201611-201701)

GFS14 (89.19,82.20)

FV3GFDLMP (91.82,83.56)

CERES (103.3,94.62)
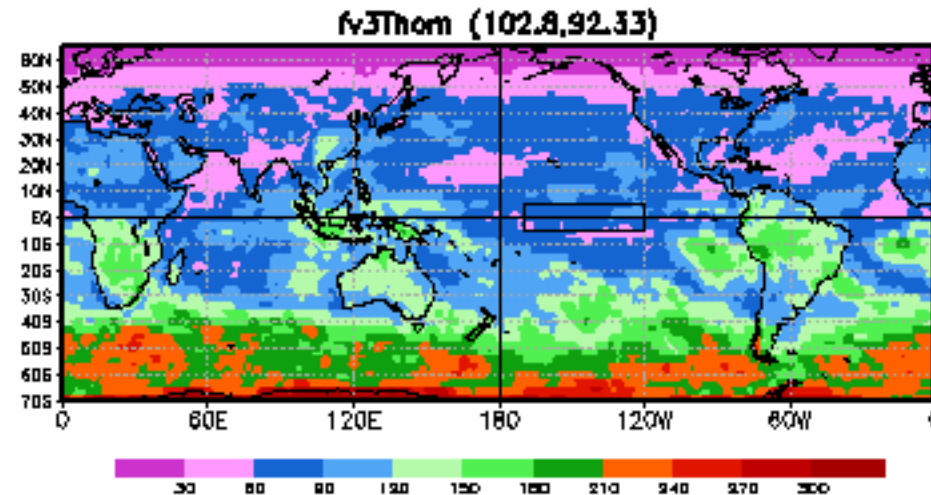
FV3TH (102.8,92.33)

TOA USW in FV3TH is close to CERES
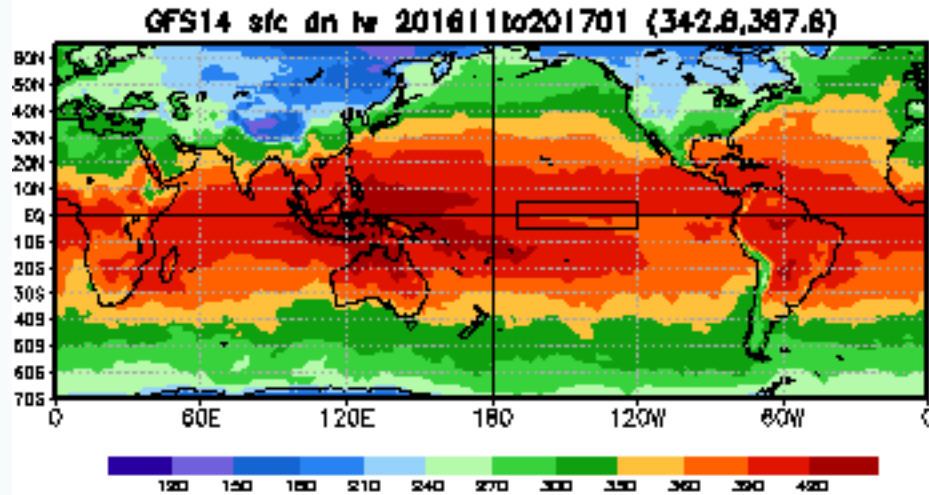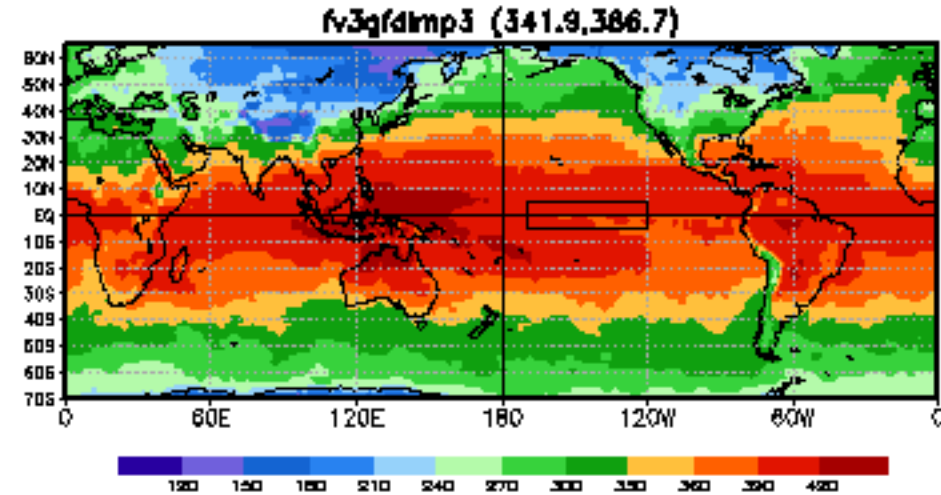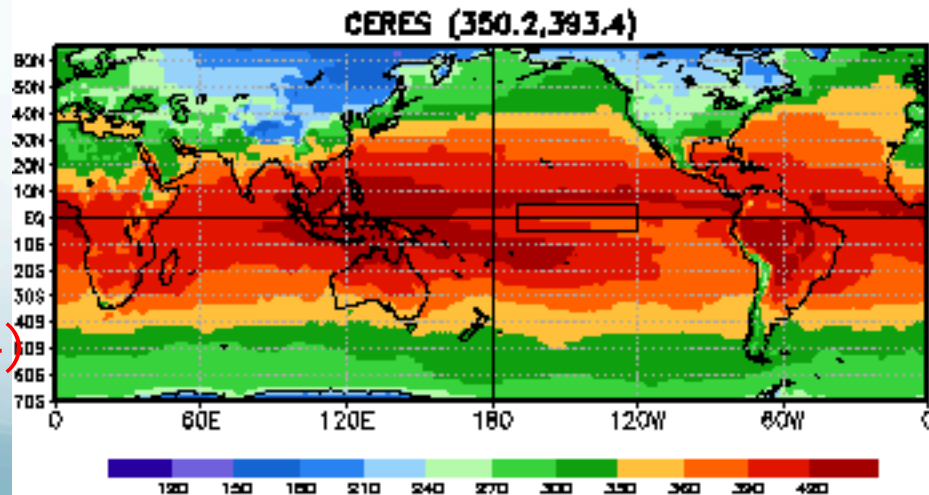
SFC DOWN LW (201611-201701)
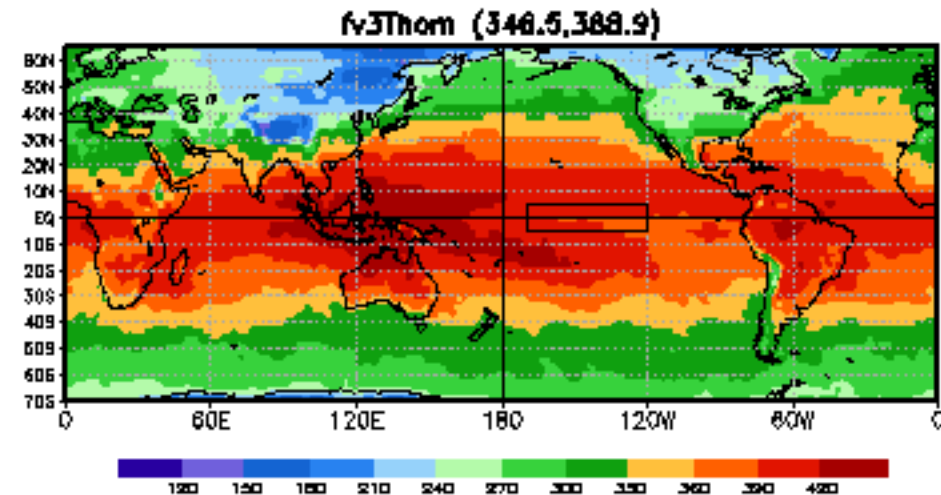

GFS14
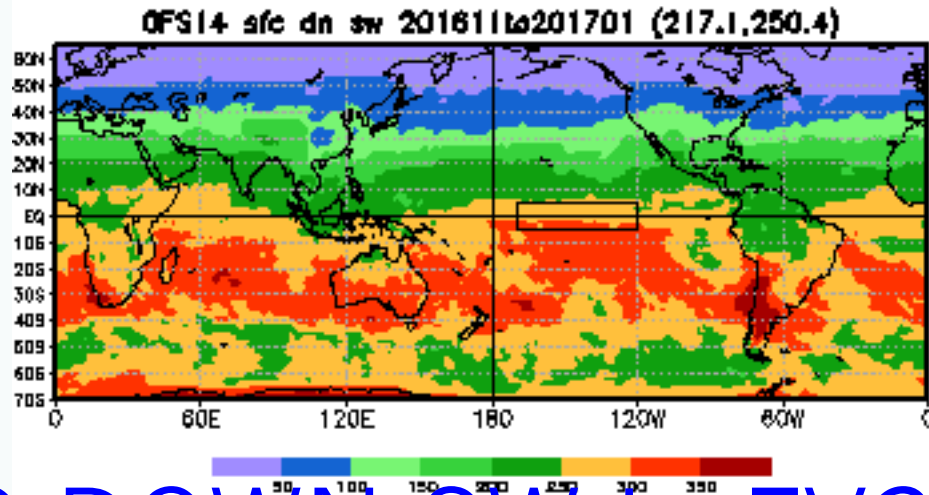(342.8,387.8)

FV3GFDLMP
(341,9,386.7)

CERES
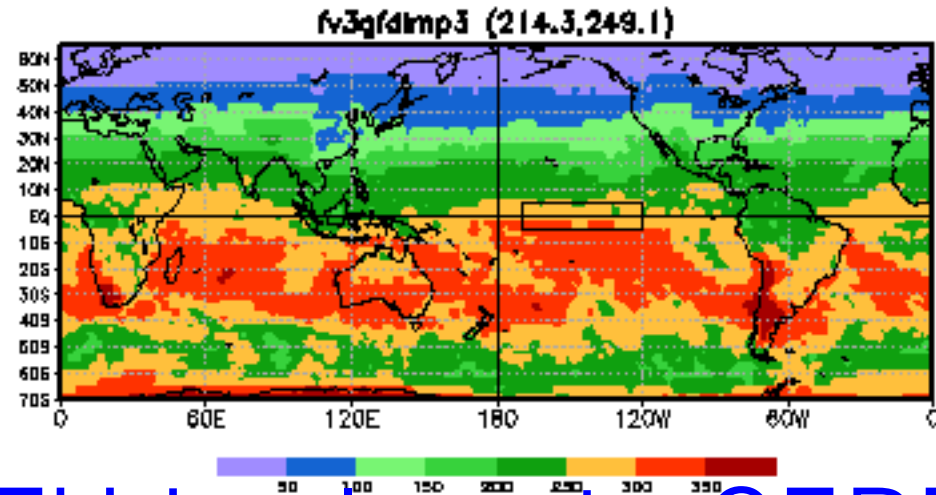(350.2,393.4)

FV3TH
(346.5,388.9)

SFC DOWN SW (201611-201701)

GFS14
(217.1,250.4)

FV3GFDLMP
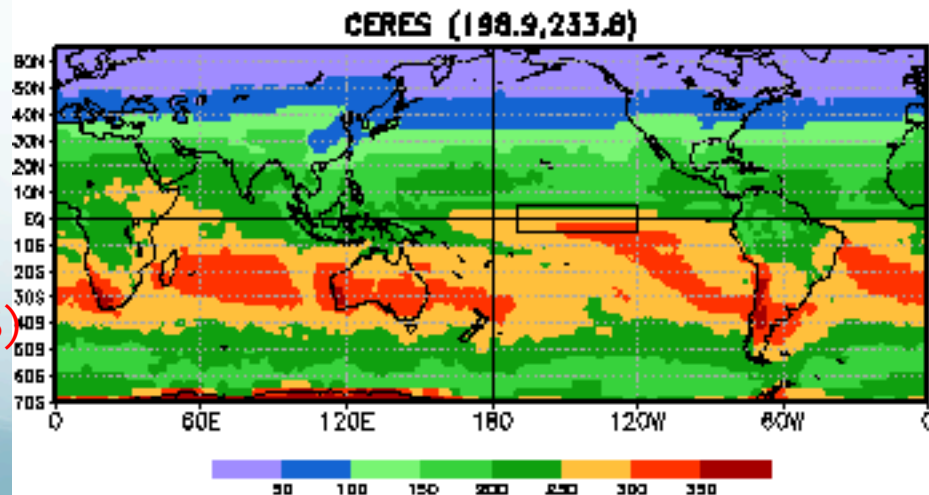(214.3,249.1)

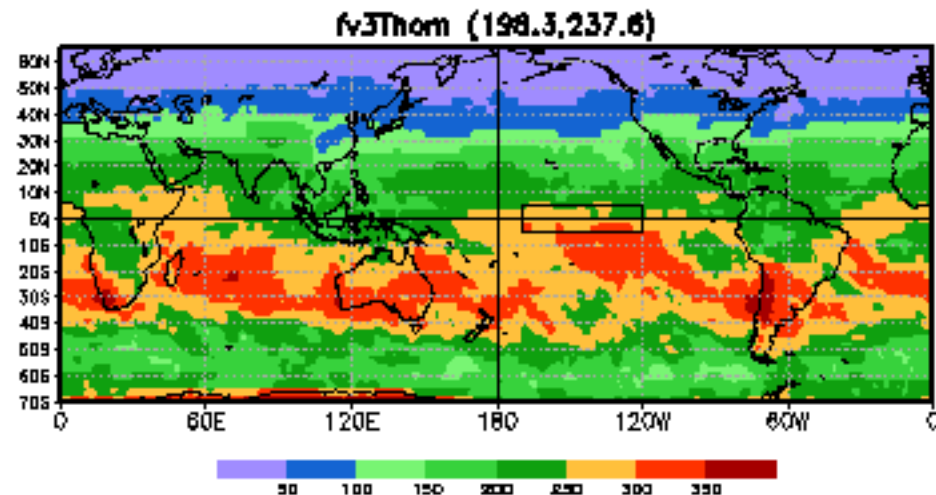GFS14 sfc dn sw 201611to201701 (217.1,250.4)

fv3gfdlmp3 (214.3,249.1)

SFC DOWN SW in FV3TH is close to CERES

CERES (198.9,233.8)
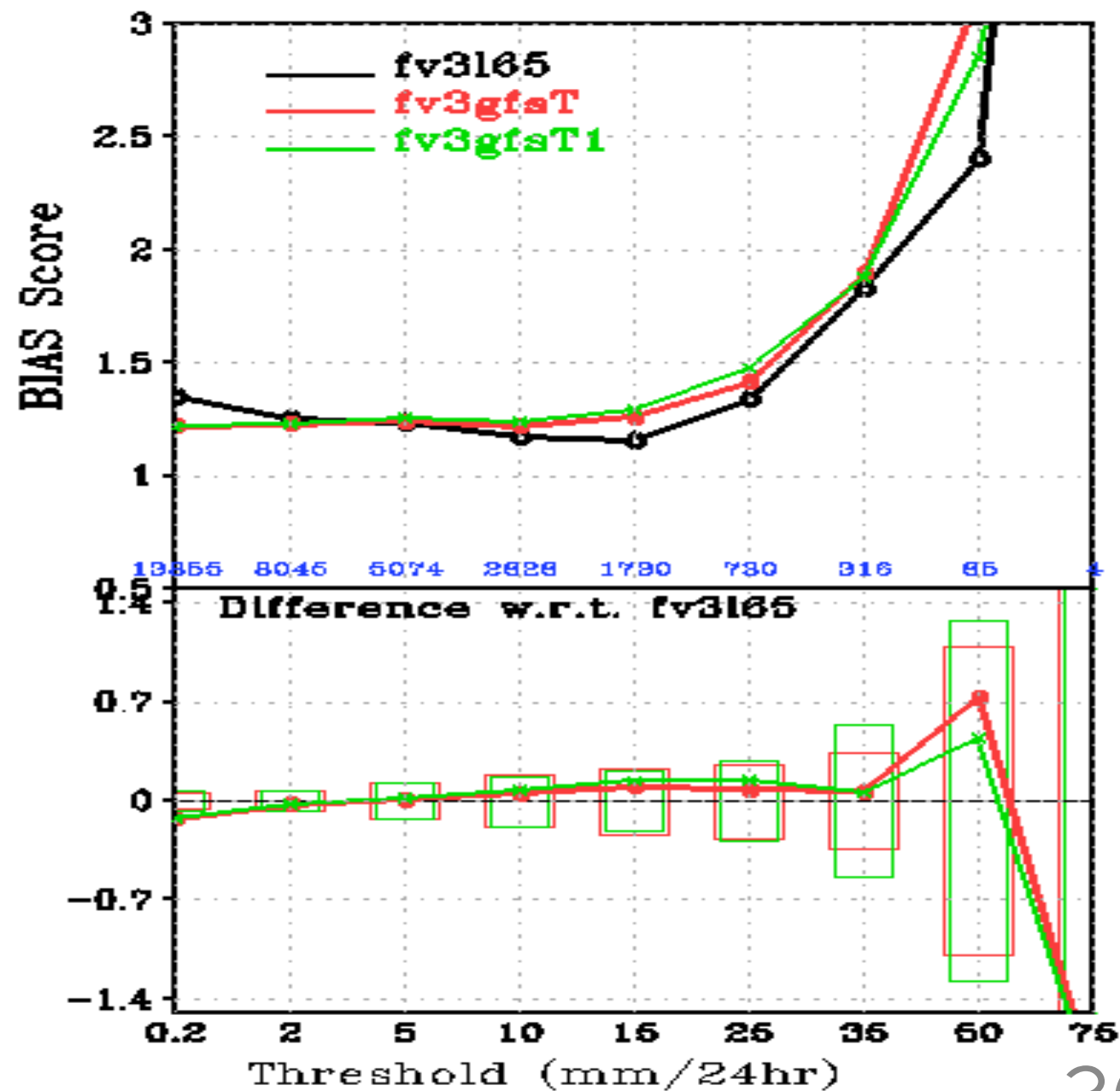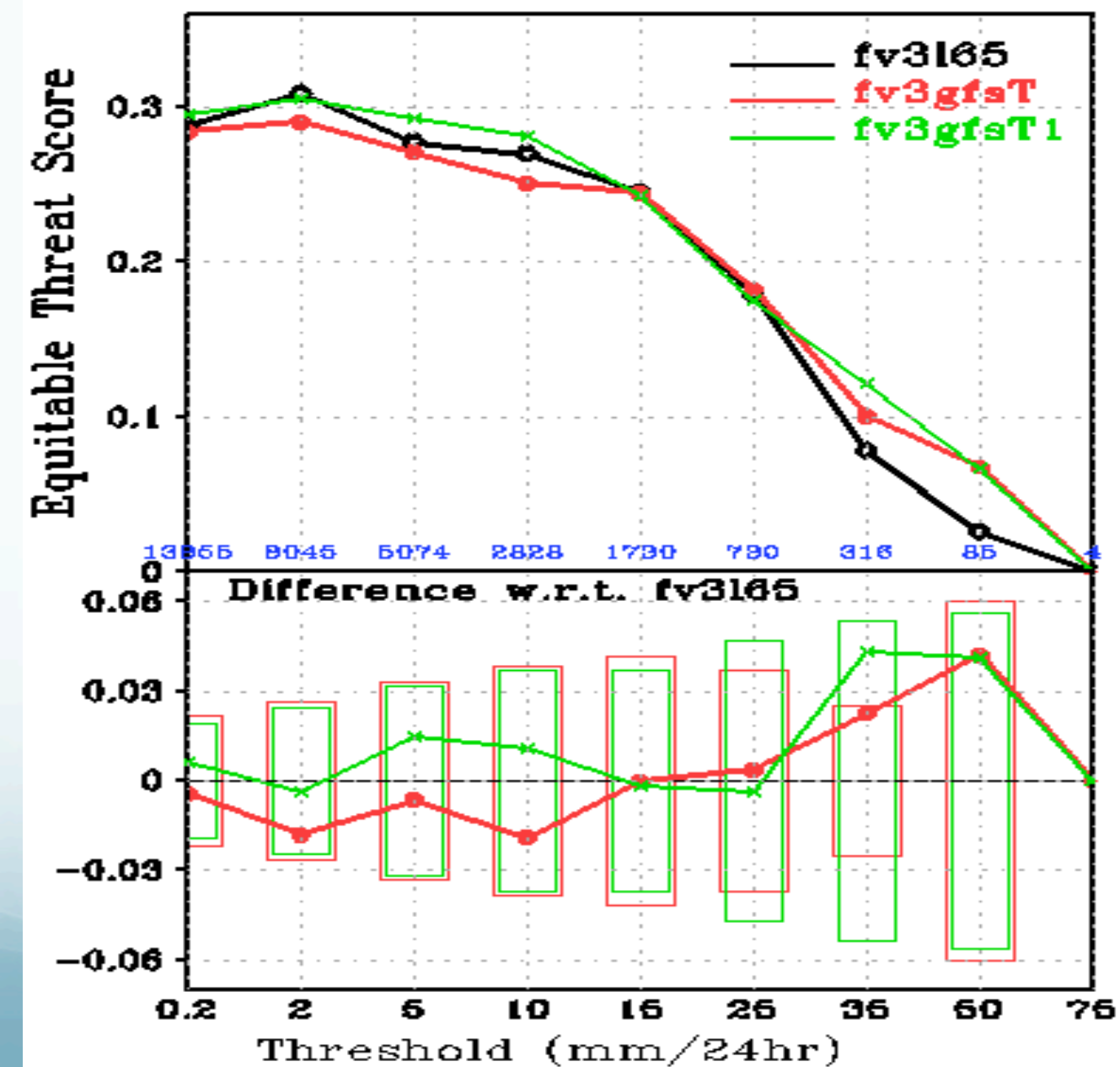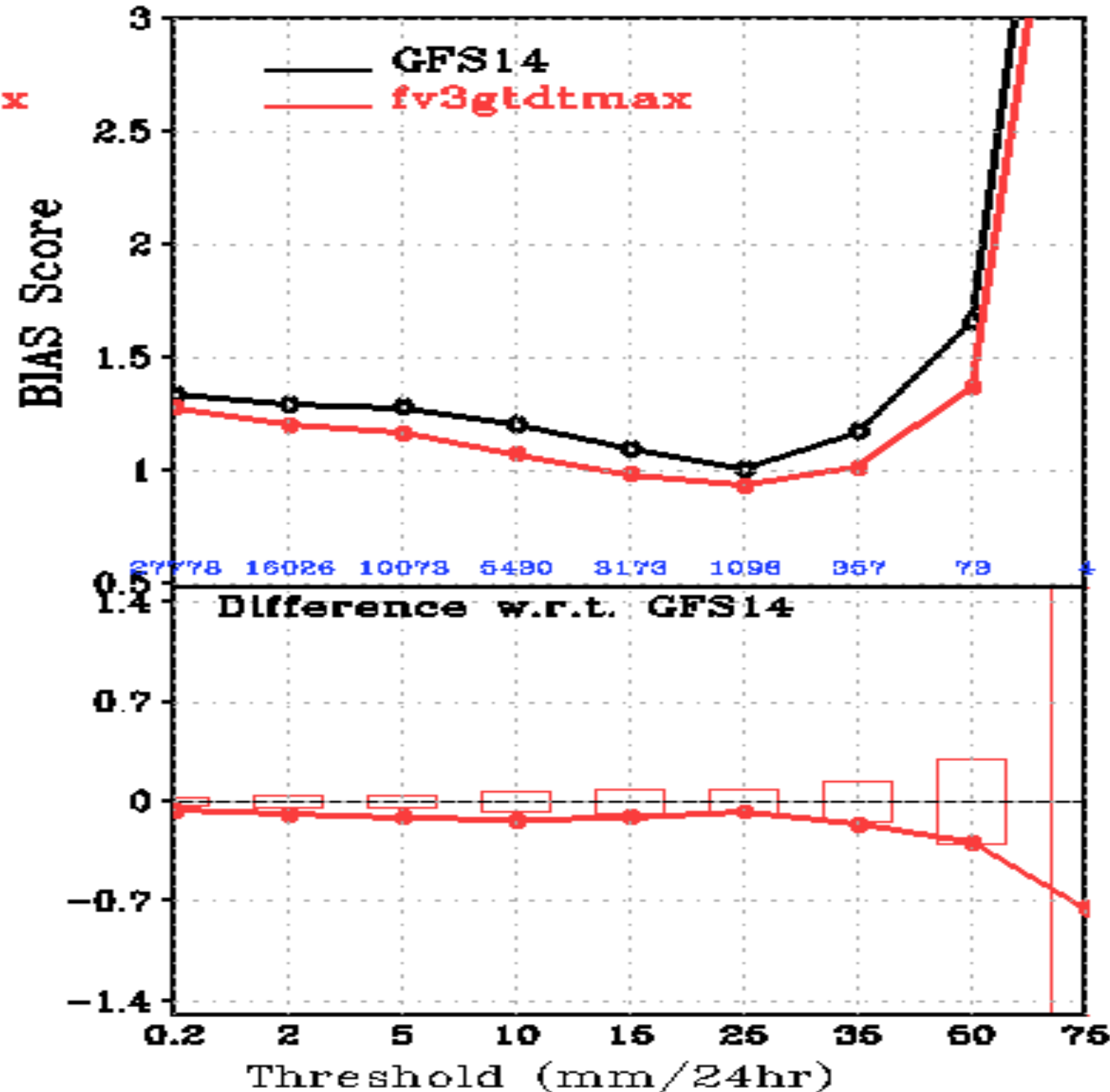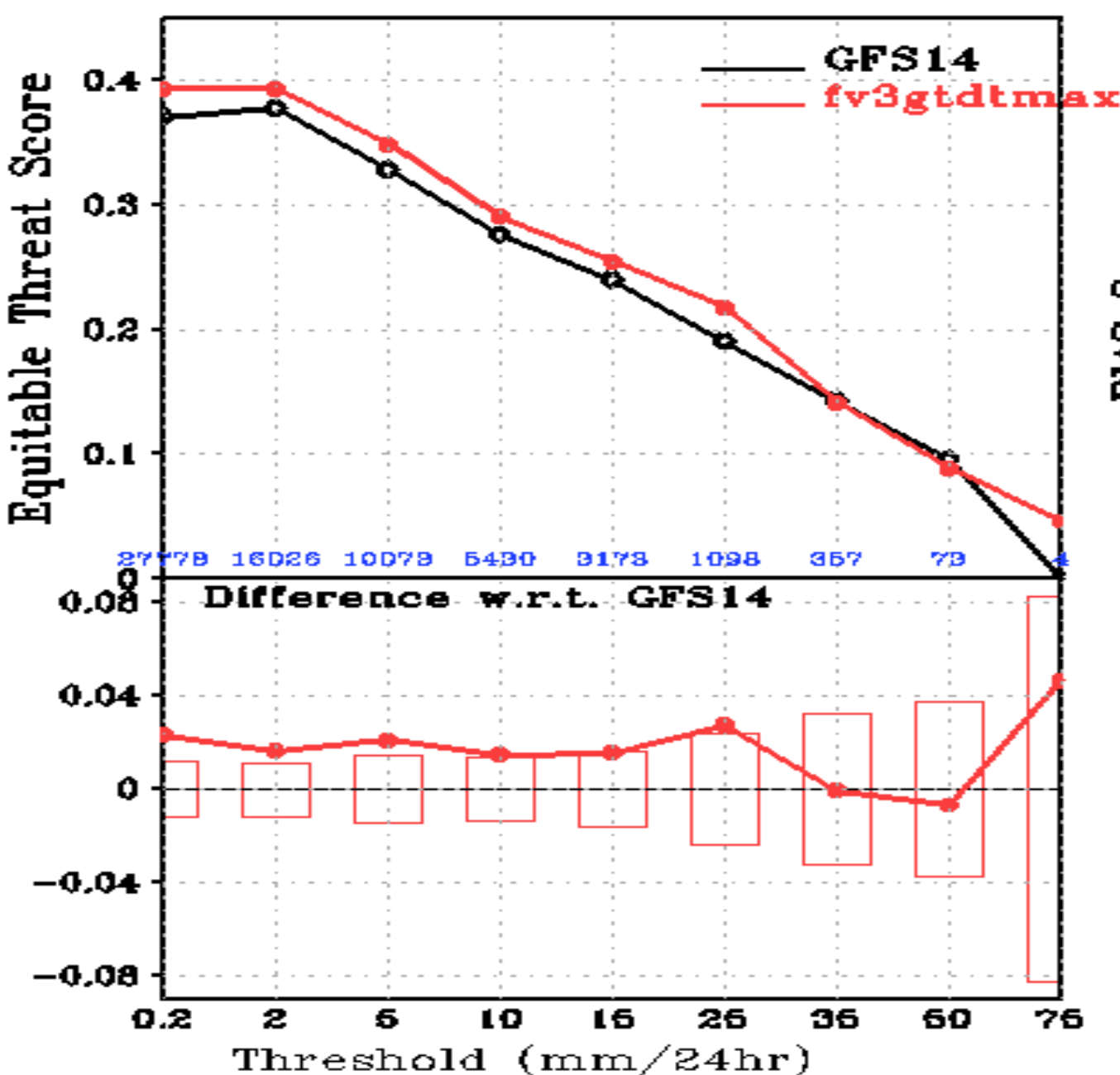
fv3Thom (198.3,237.6)

CERES
(198.9,233.8)

FV3TH
(198.3,237.6)

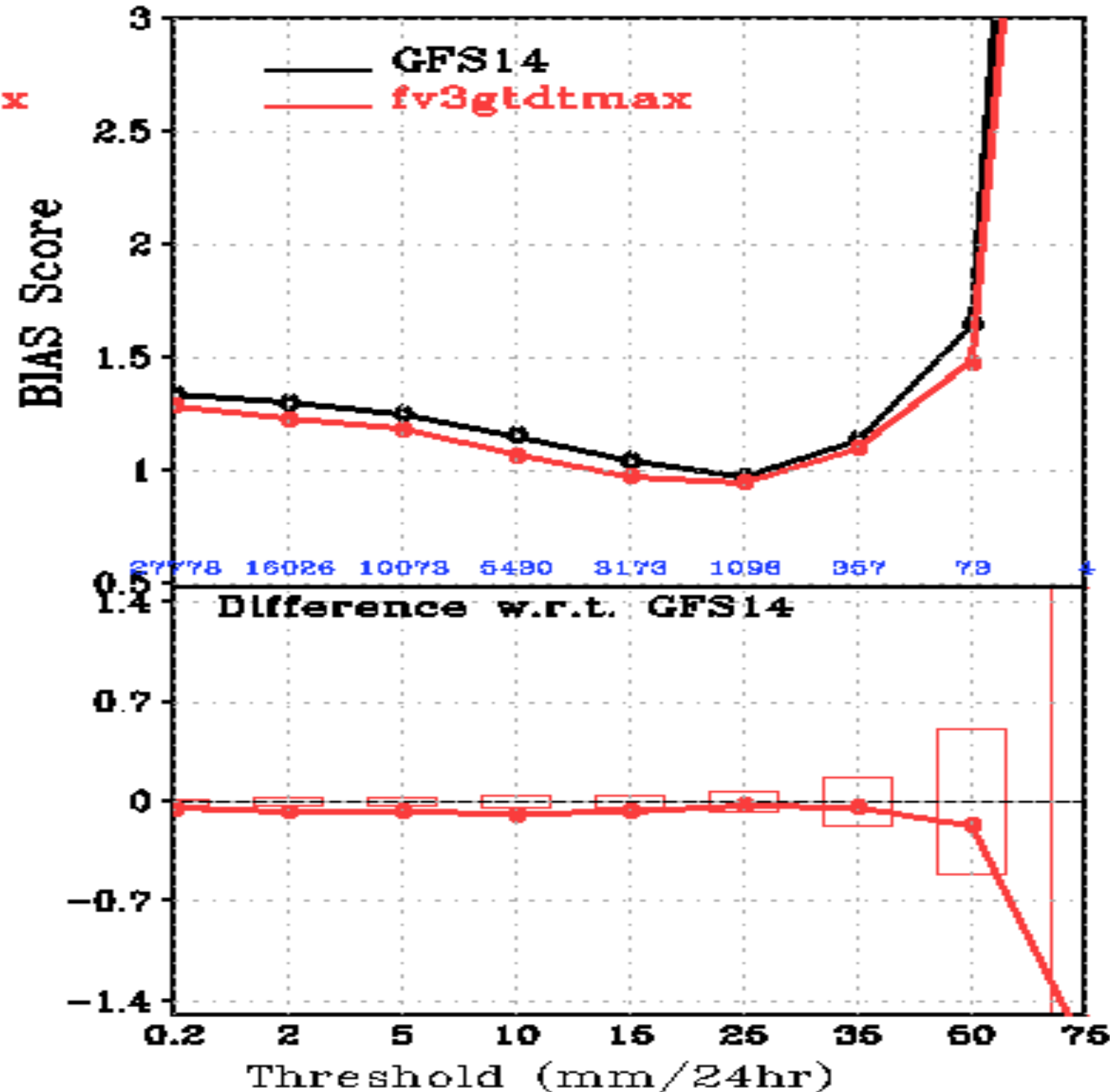CONUS Precip Skill Scores, f132—f156, 05jan2017—28feb2017 00Z Cycle
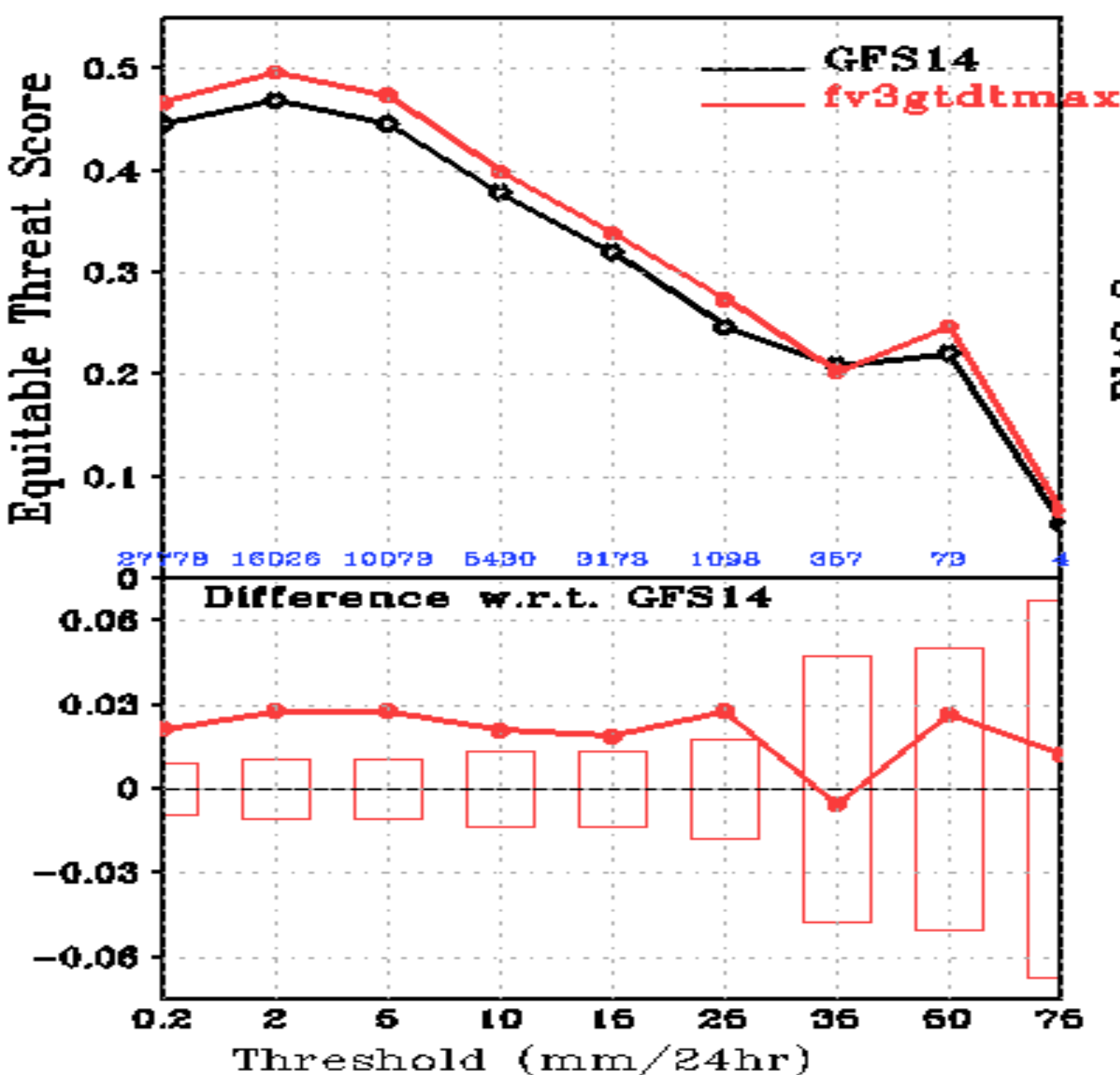
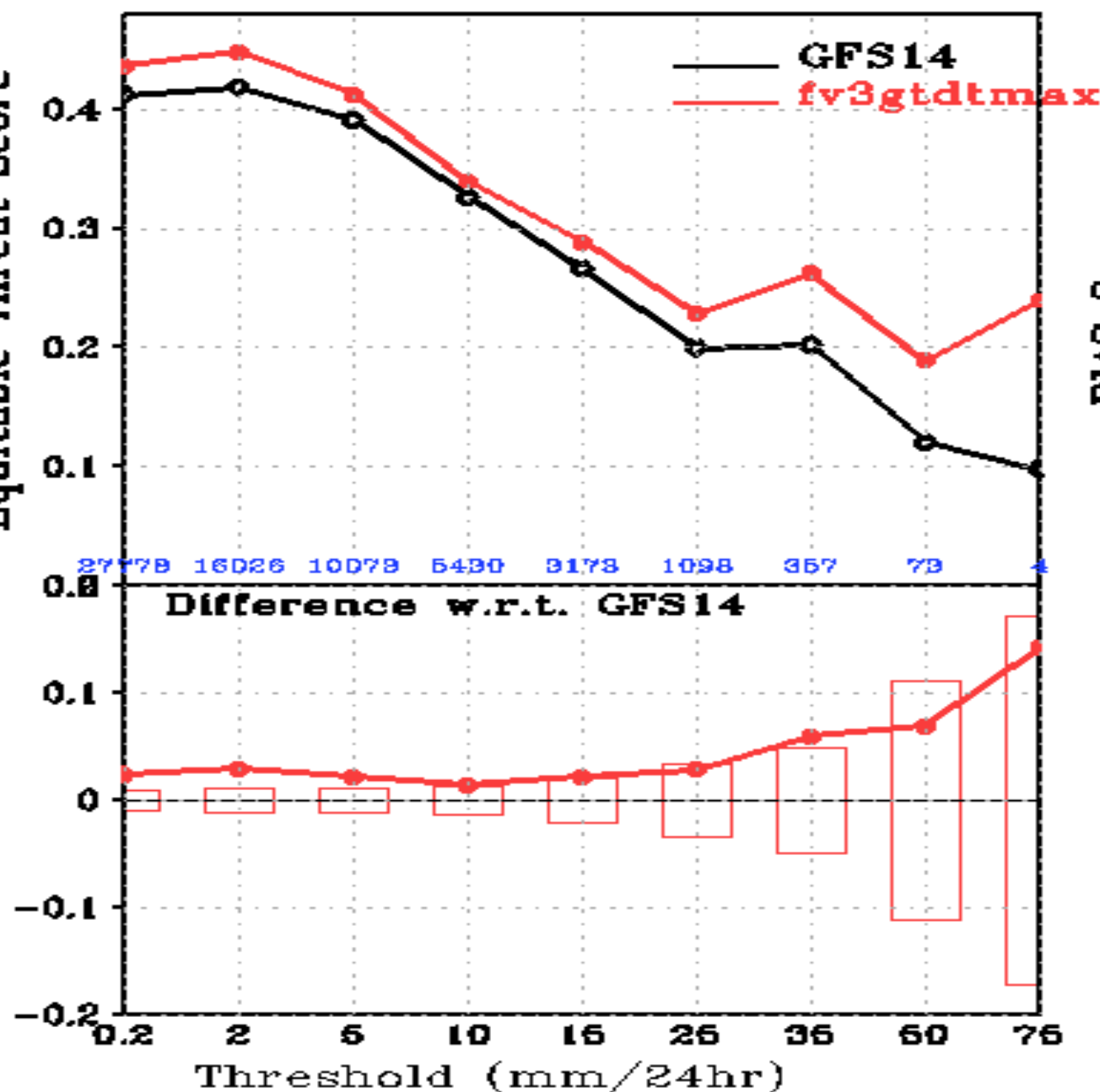CONUS Precip Skill Scores, f60–f84, 10jul2016–29jun2017 00Z Cycle

Differences outside of the hollow bars are 95% significant based on 10000 Monte Carlo Tests

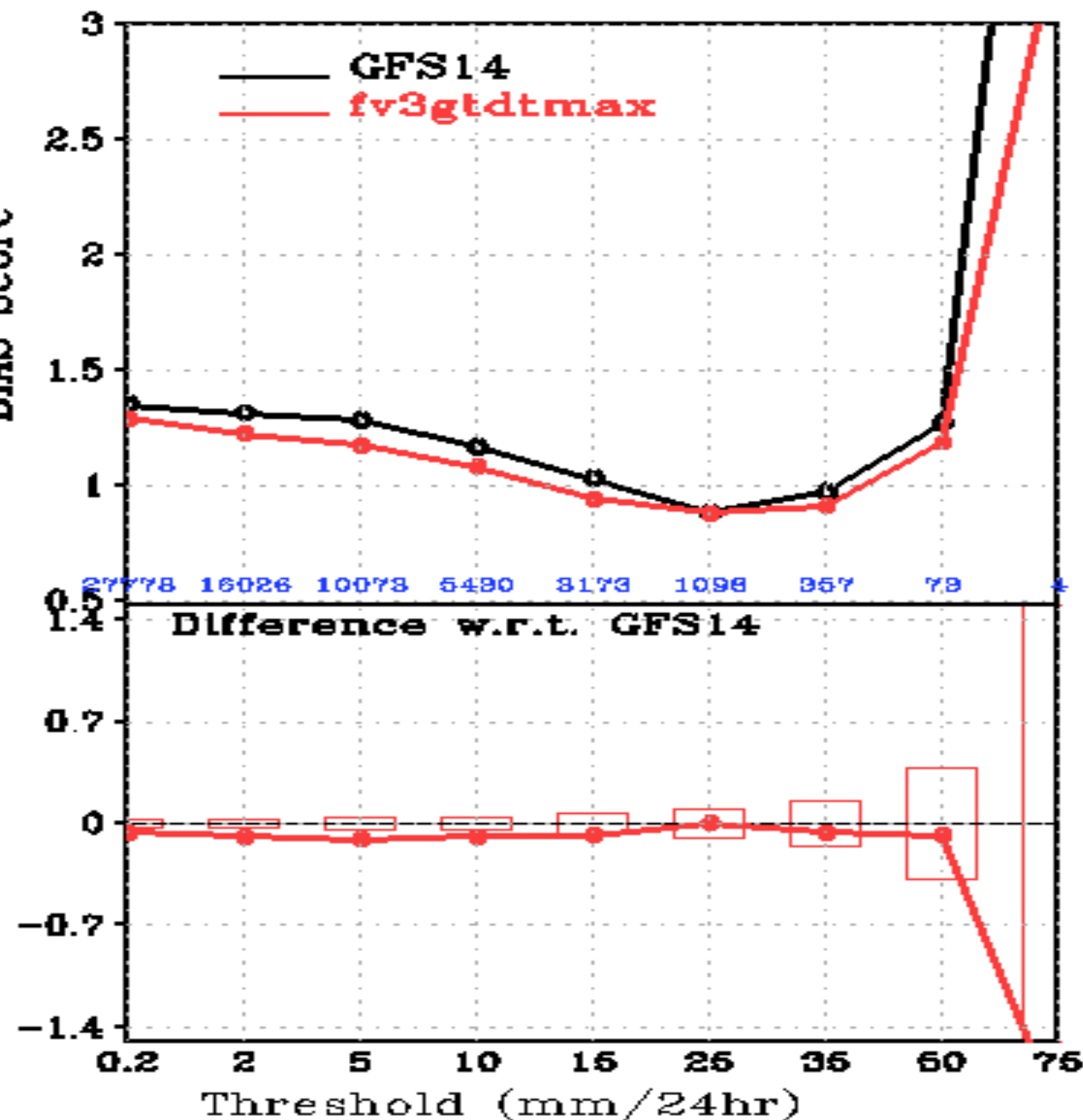CONUS Precip Skill Scores, f12−f36, 10jul2016−29jun2017 00Z Cycle

Differences outside of the hollow bars are 95% significant based on 10000 Monte Carlo Tests

CONUS Precip Skill Scores, f36–f60, 10jul2016–29jun2017 00Z Cycle

Differences outside of the hollow bars are 95% significant based on 10000 Monte Carlo Tests